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Van Dorfy, Jr. et al.

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(54) **FURNACE AND SYSTEM FOR HEAT TREATING MATERIAL**

(71) Applicant: **Lone Star Heat Treating Corporation**, Houston, TX (US)

(72) Inventors: **Michael R. Van Dorfy, Jr.**, Houston, TX (US); **Clair J. Van Rooyen**, Houston, TX (US); **Kevin Bahrt**, Houston, TX (US)

(73) Assignee: **Lone Start Heat Treating Corporation**, Houston, TX (US)

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(65) **Prior Publication Data**

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(51) **Int. Cl.**

C21D 9/00	(2006.01)
F27B 9/10	(2006.01)
F27B 9/20	(2006.01)
F27B 9/30	(2006.01)
F27B 9/38	(2006.01)
C21D 9/46	(2006.01)

(52) **U.S. Cl.**

CPC ***C21D 9/0062*** (2013.01); ***F27B 9/10*** (2013.01); ***F27B 9/20*** (2013.01); ***F27B 9/30*** (2013.01); ***F27B 9/38*** (2013.01); *C21D 9/0025* (2013.01); *C21D 9/46* (2013.01)

(58) **Field of Classification Search**

CPC C21D 9/0062; C21D 9/0025
USPC 266/256
See application file for complete search history.

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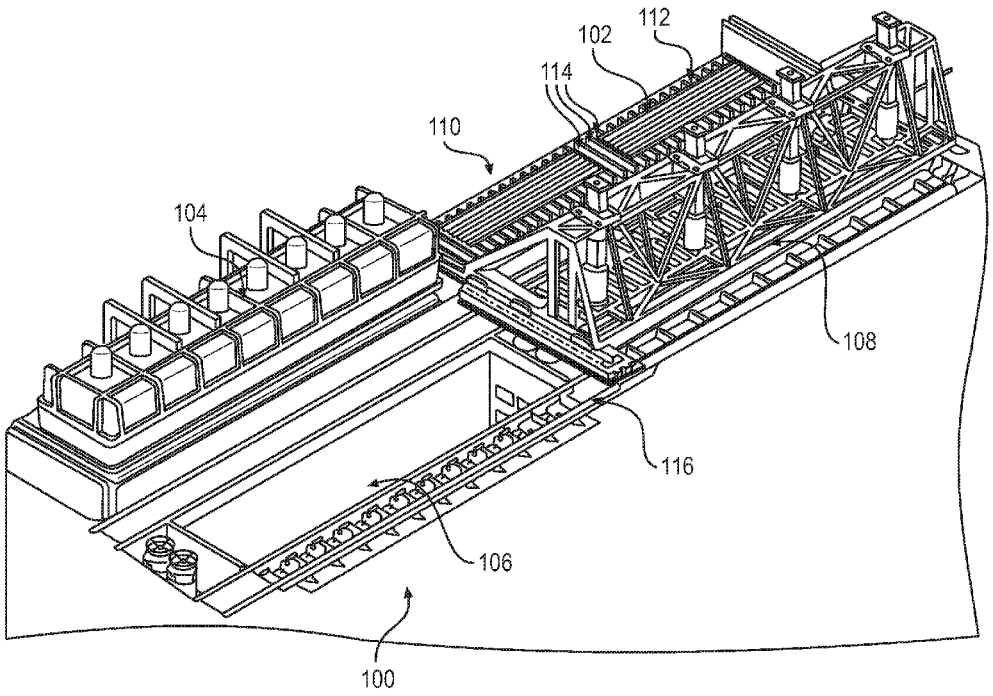
Primary Examiner — Scott Kastler
(74) *Attorney, Agent, or Firm* — Chamberlain, Hrdlicka

(57) **ABSTRACT**

A furnace for heat treating material, and a system including the furnace, includes an outer support frame and an inner shell. The inner shell is connected to and at least partially received within the outer support frame. Further, the outer support frame and the inner shell are movable to open and close to receive and remove material from the inner shell.

19 Claims, 28 Drawing Sheets



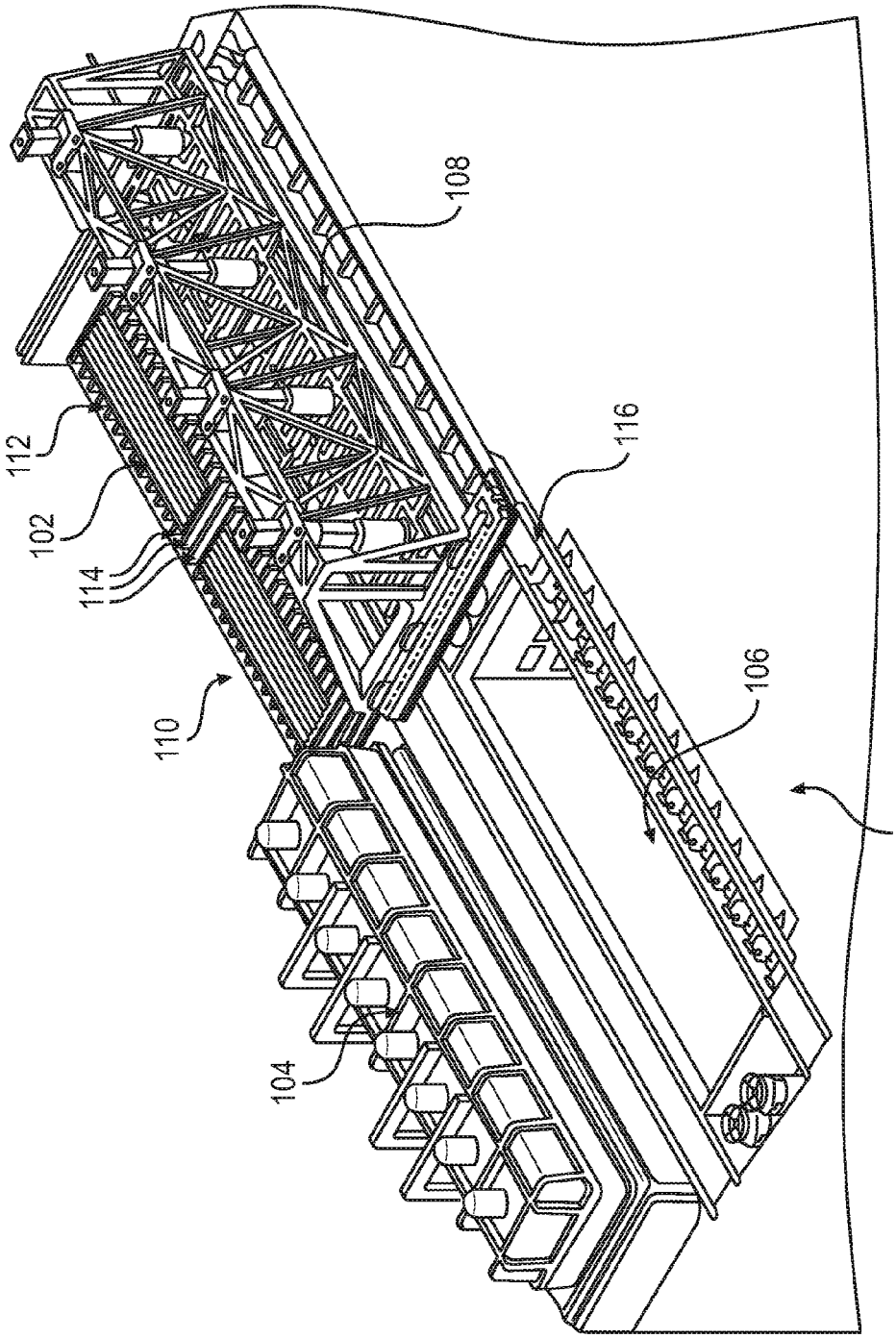


FIG. 1A

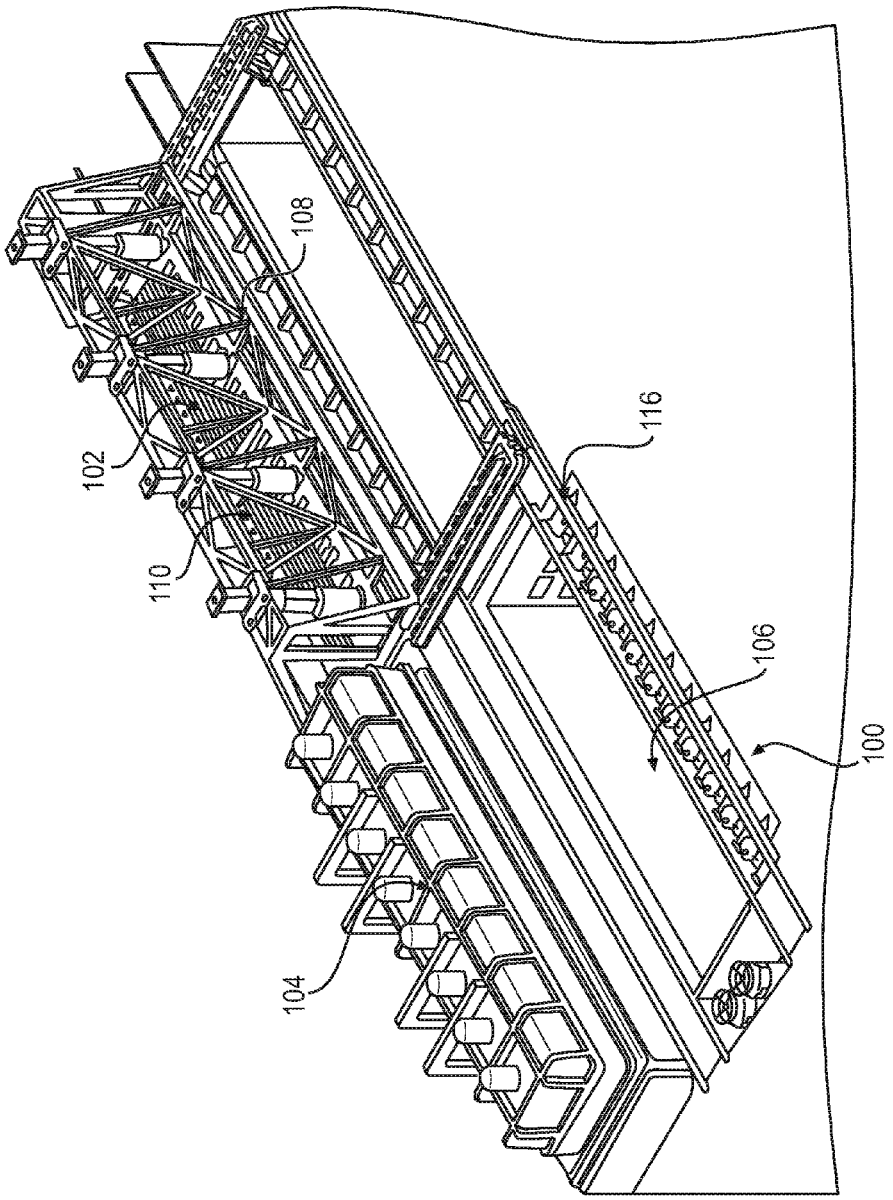


FIG. 1B

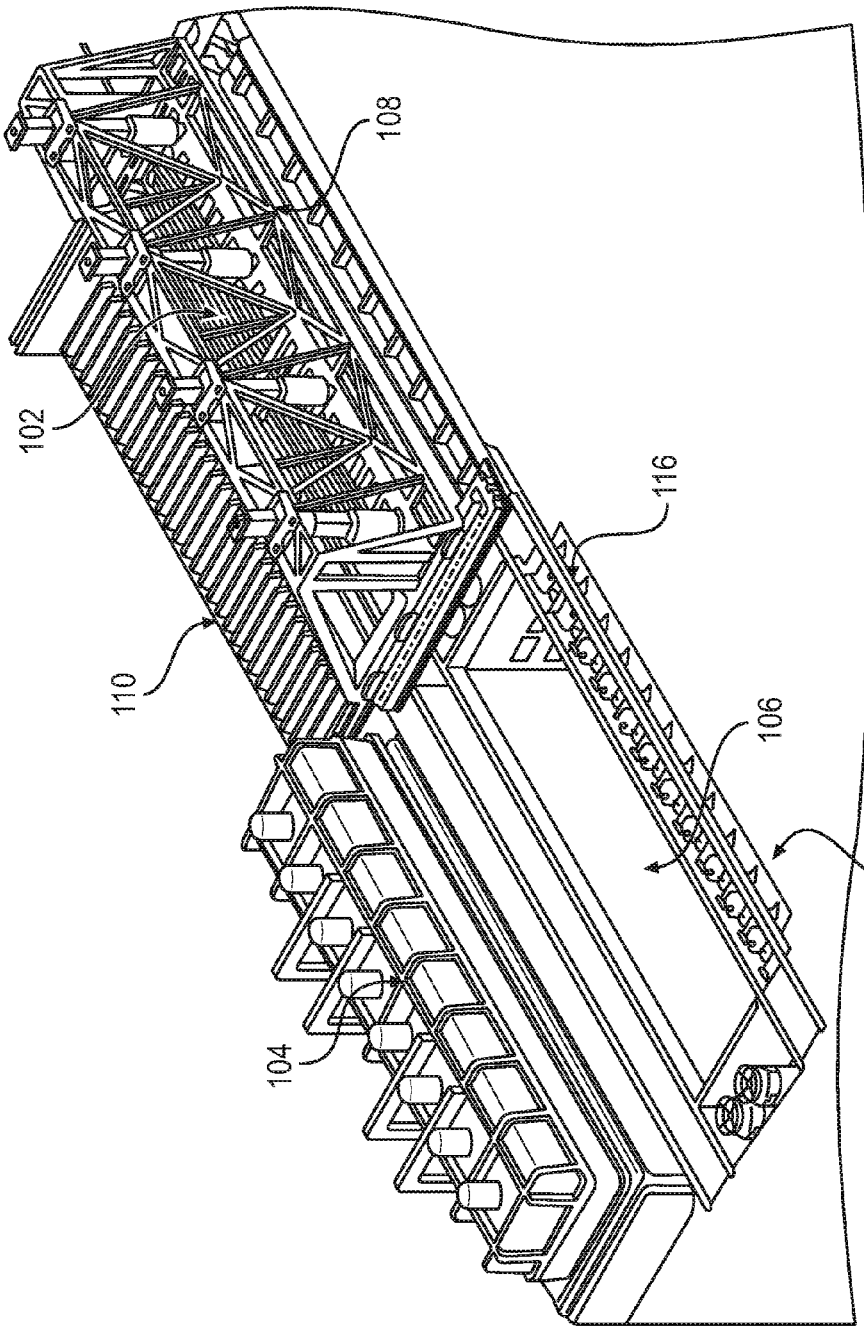


FIG. 1C

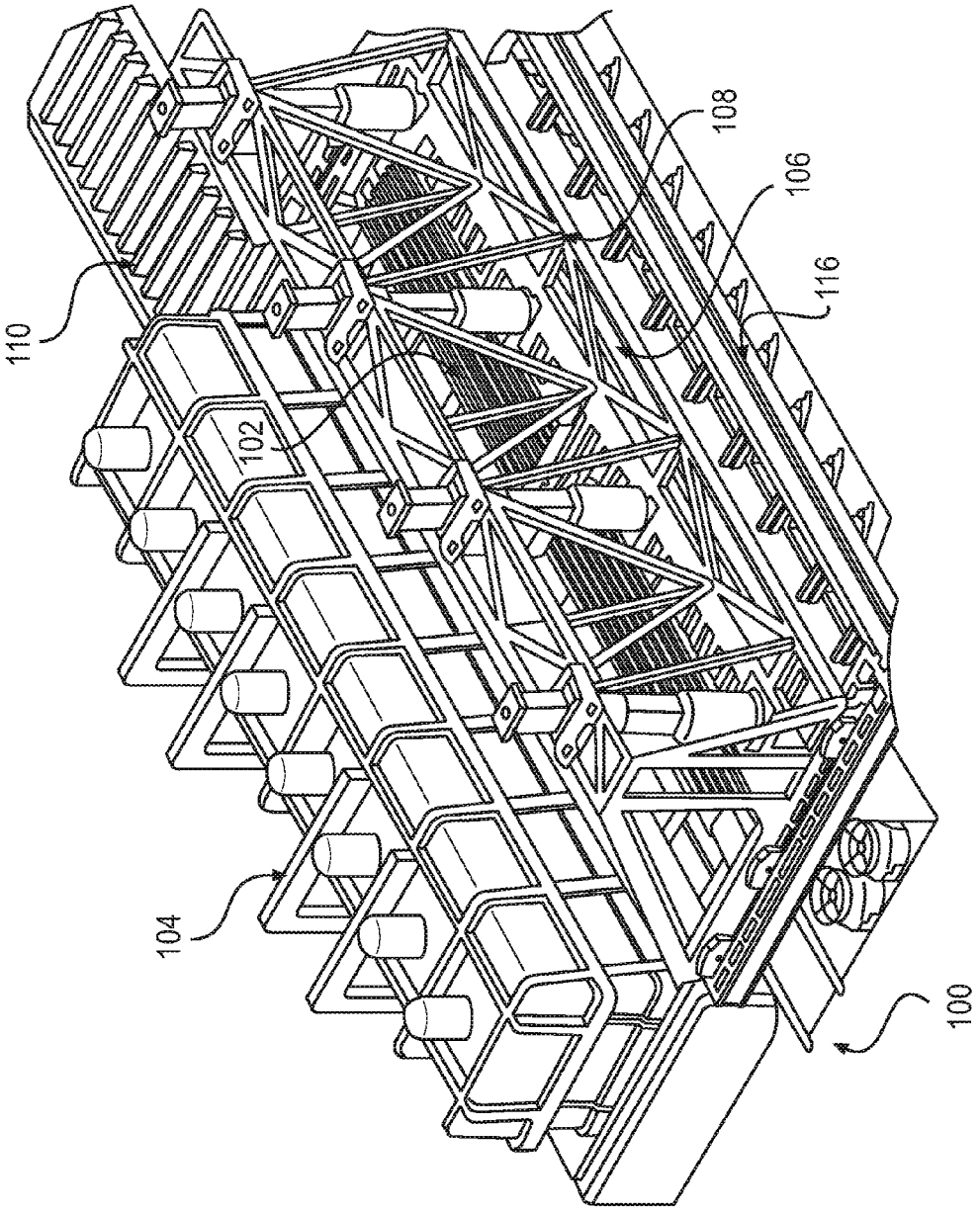


FIG. 1D

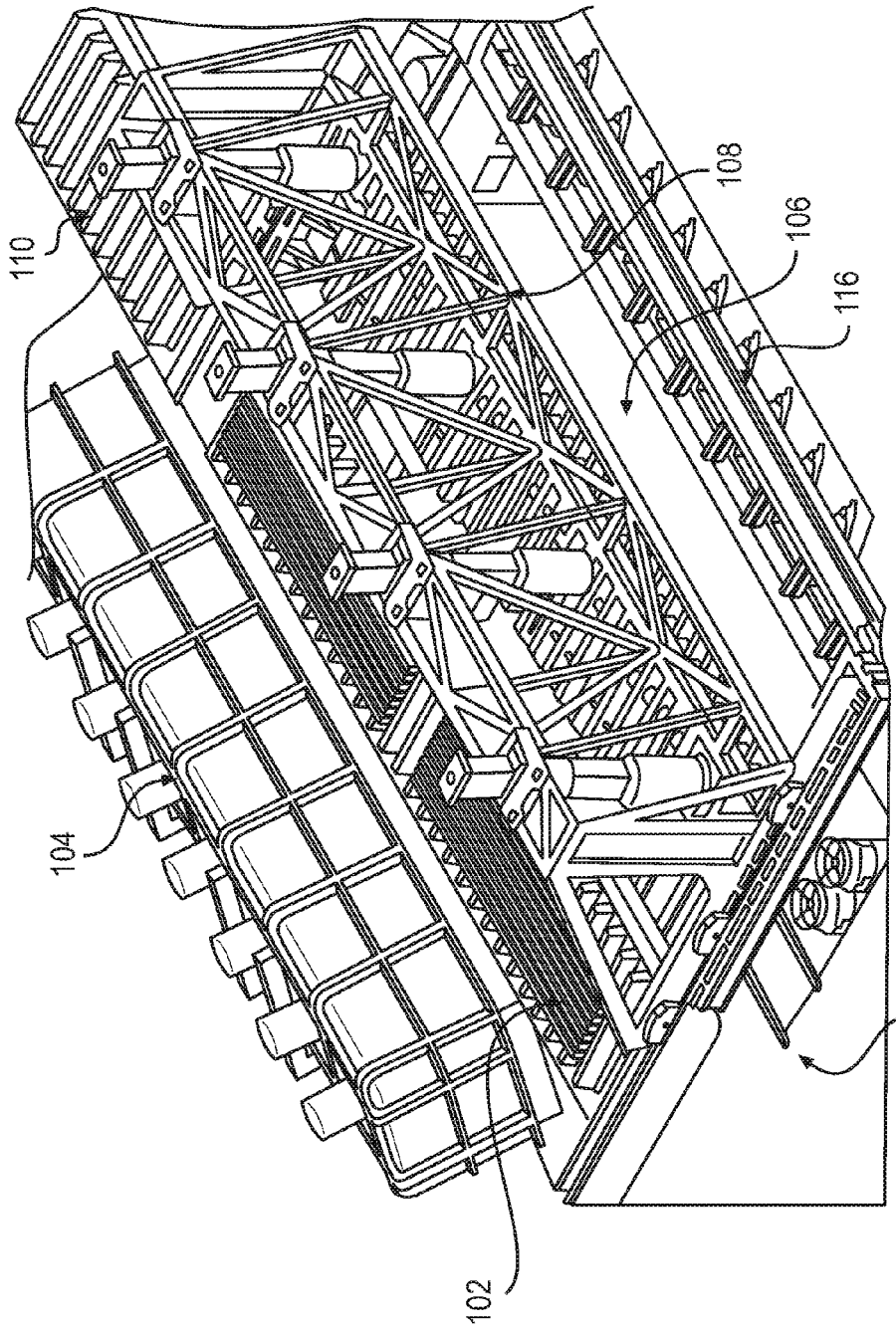


FIG. 1E

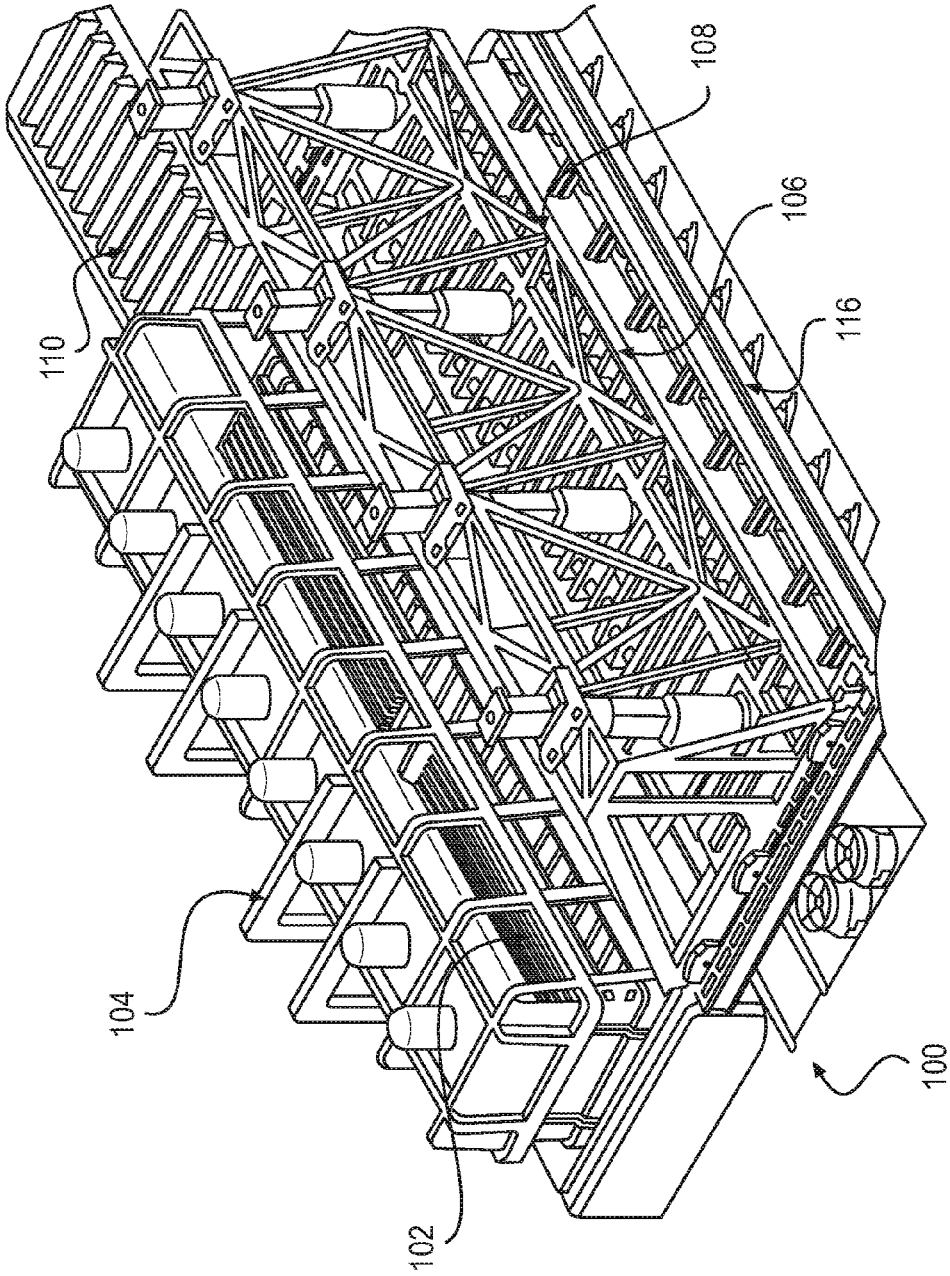


FIG. 1F

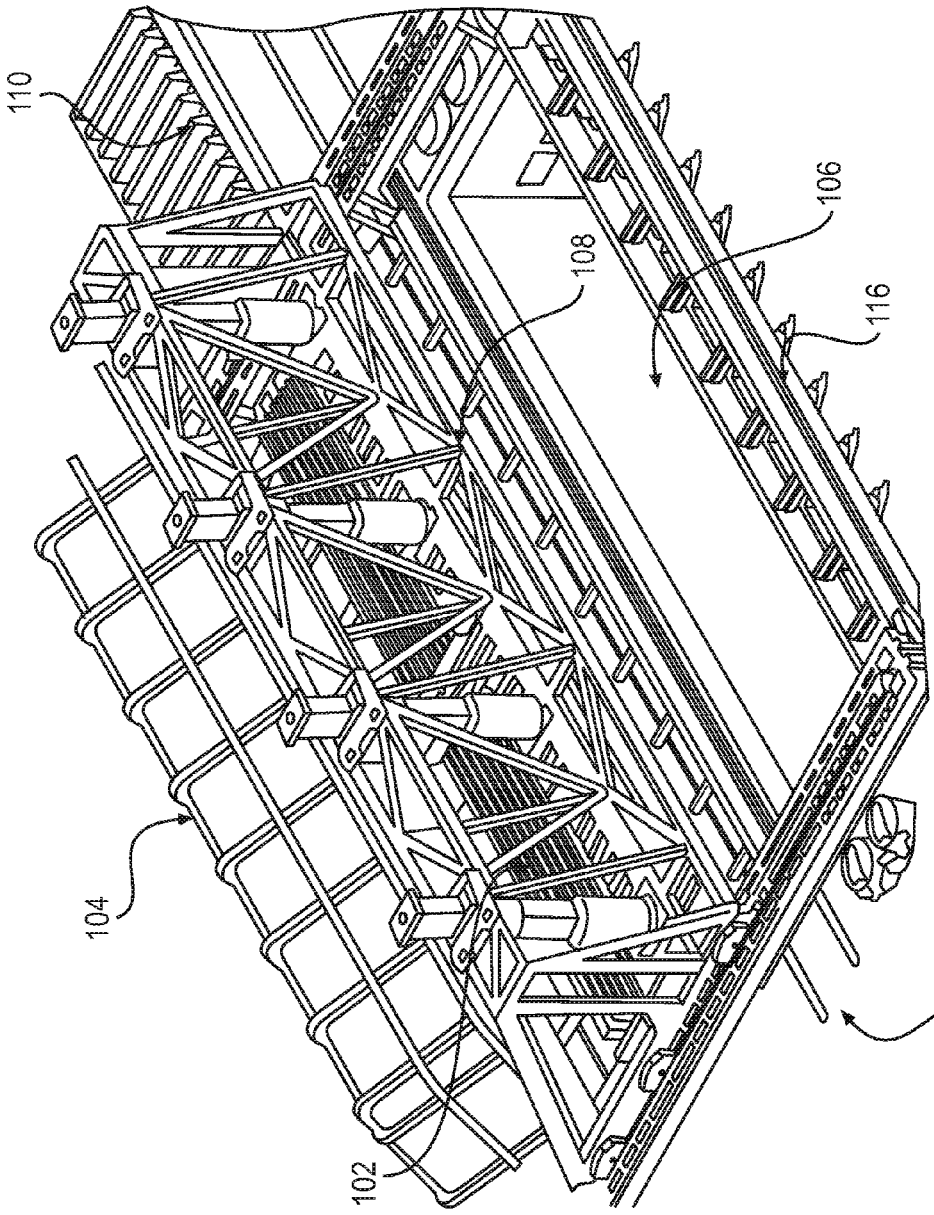


FIG. 1G

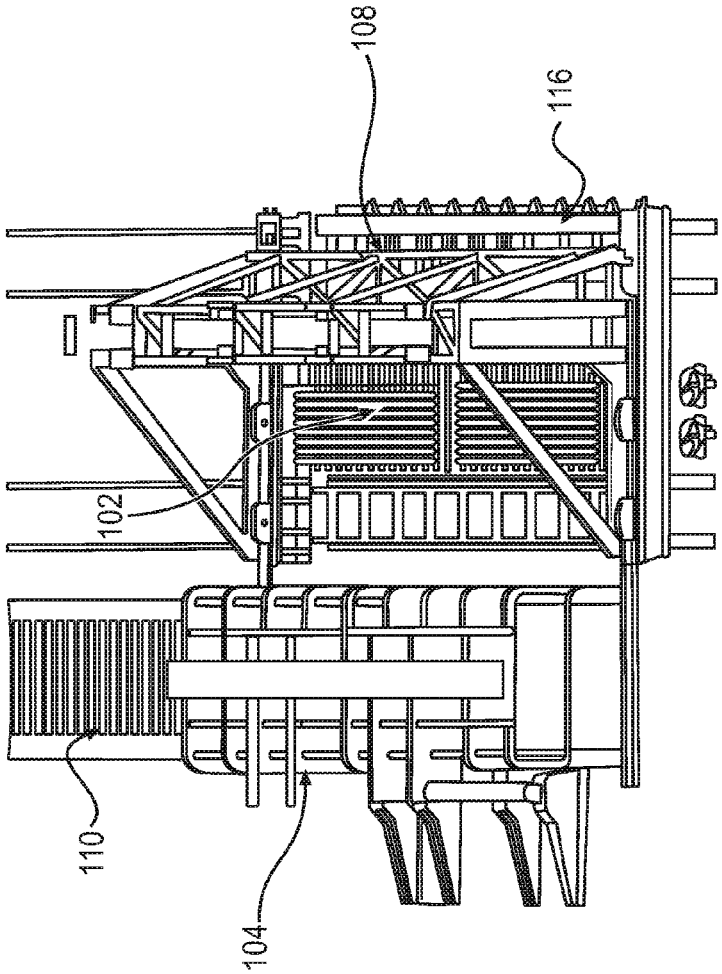


FIG. 1H

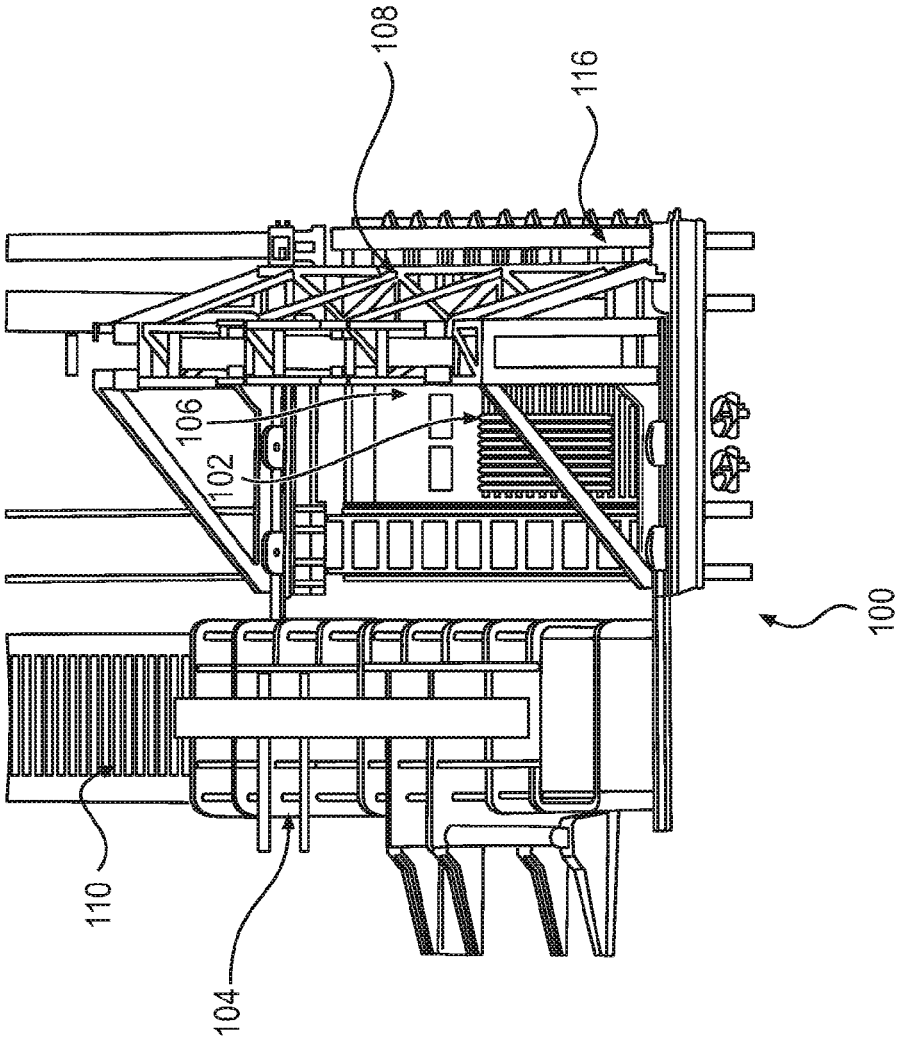


FIG. 1I

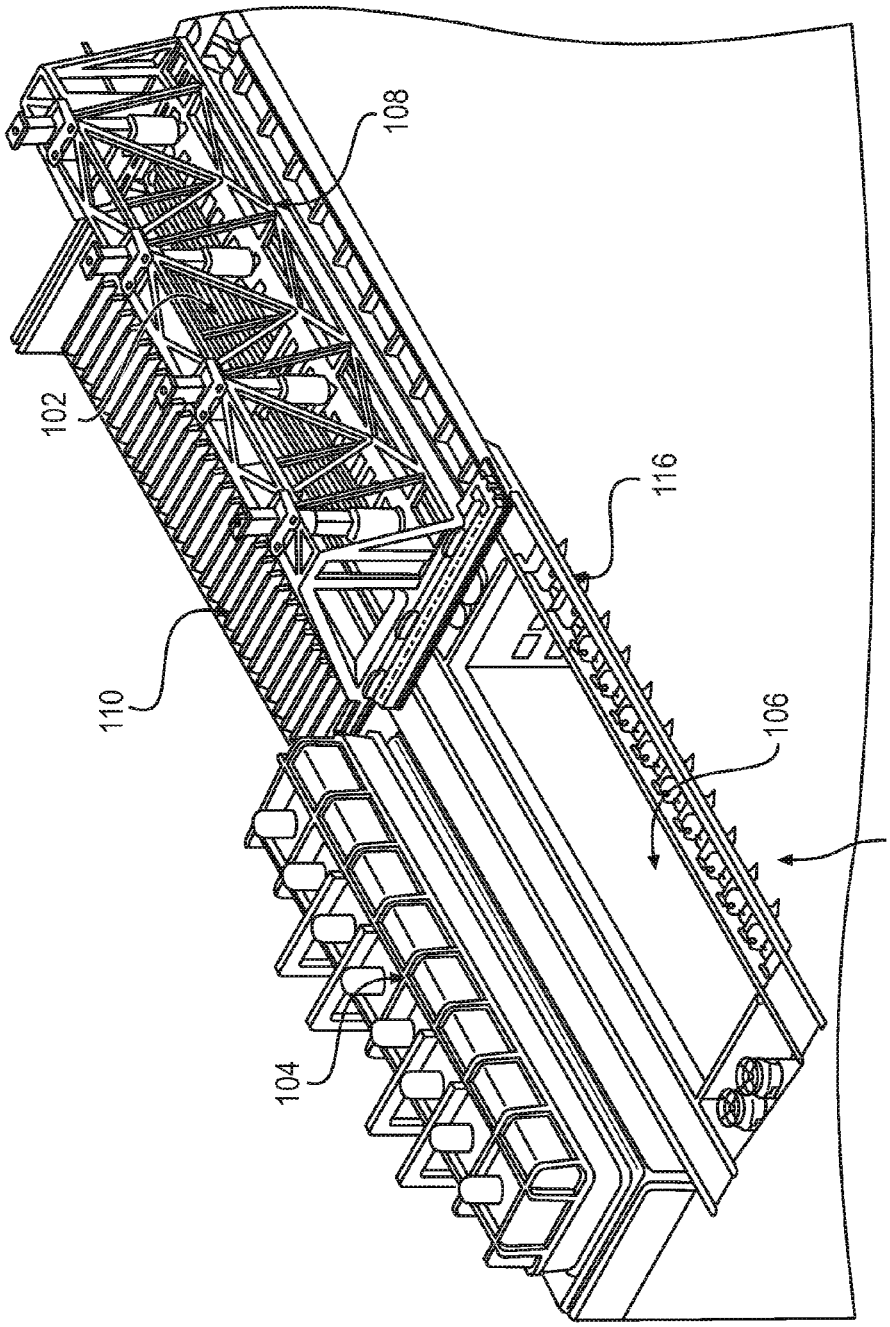


FIG. 1J

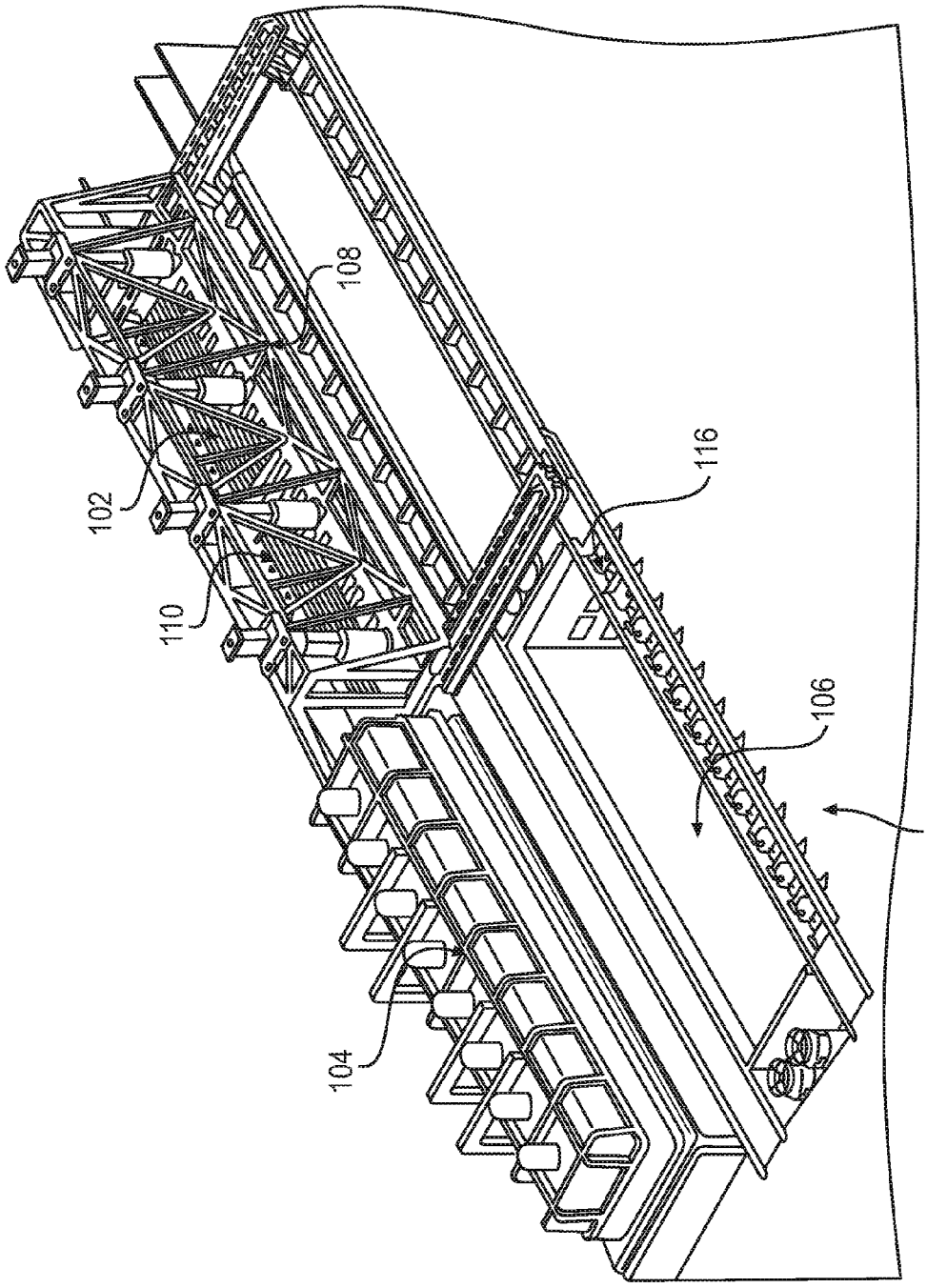


FIG. 1K

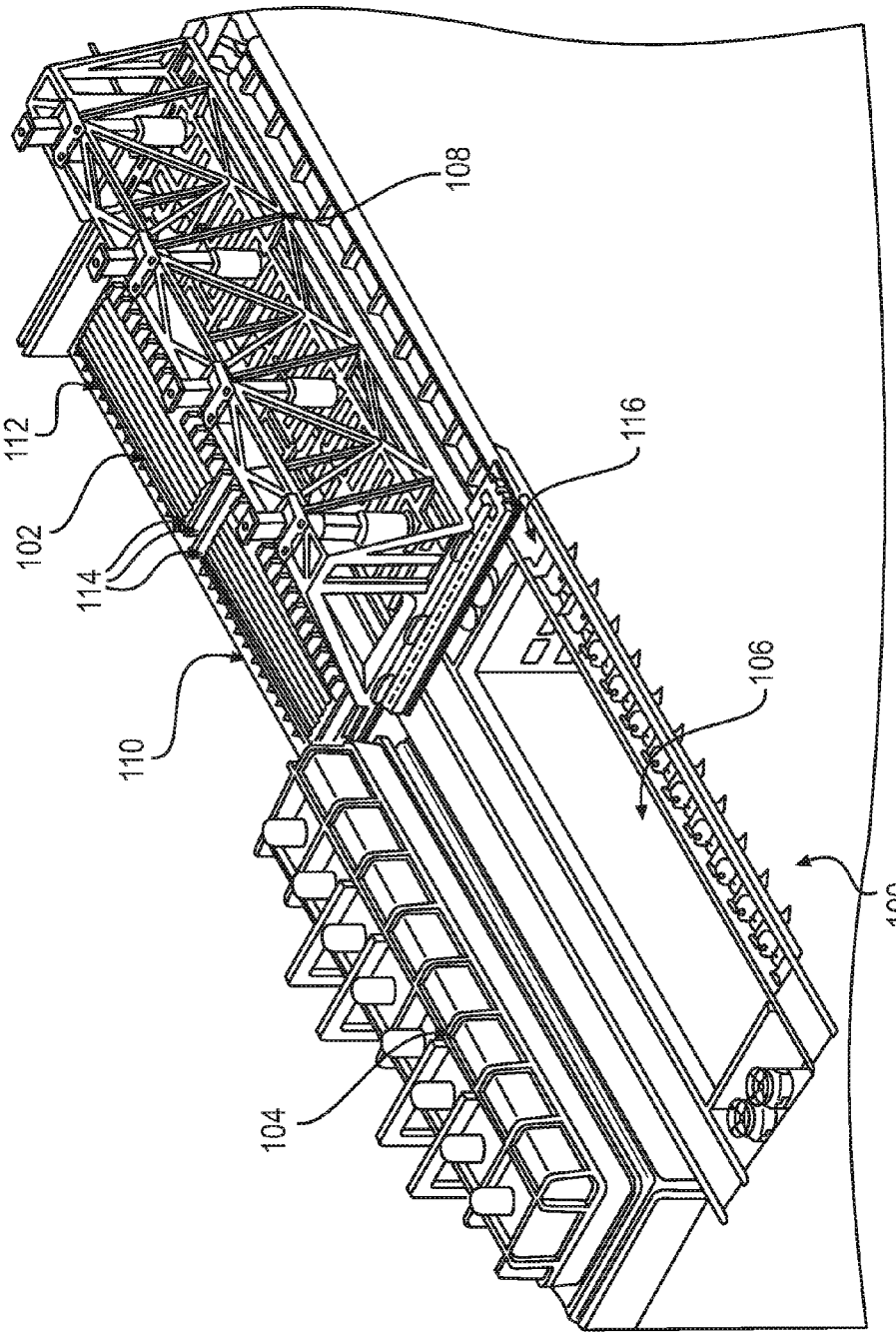


FIG. 1L

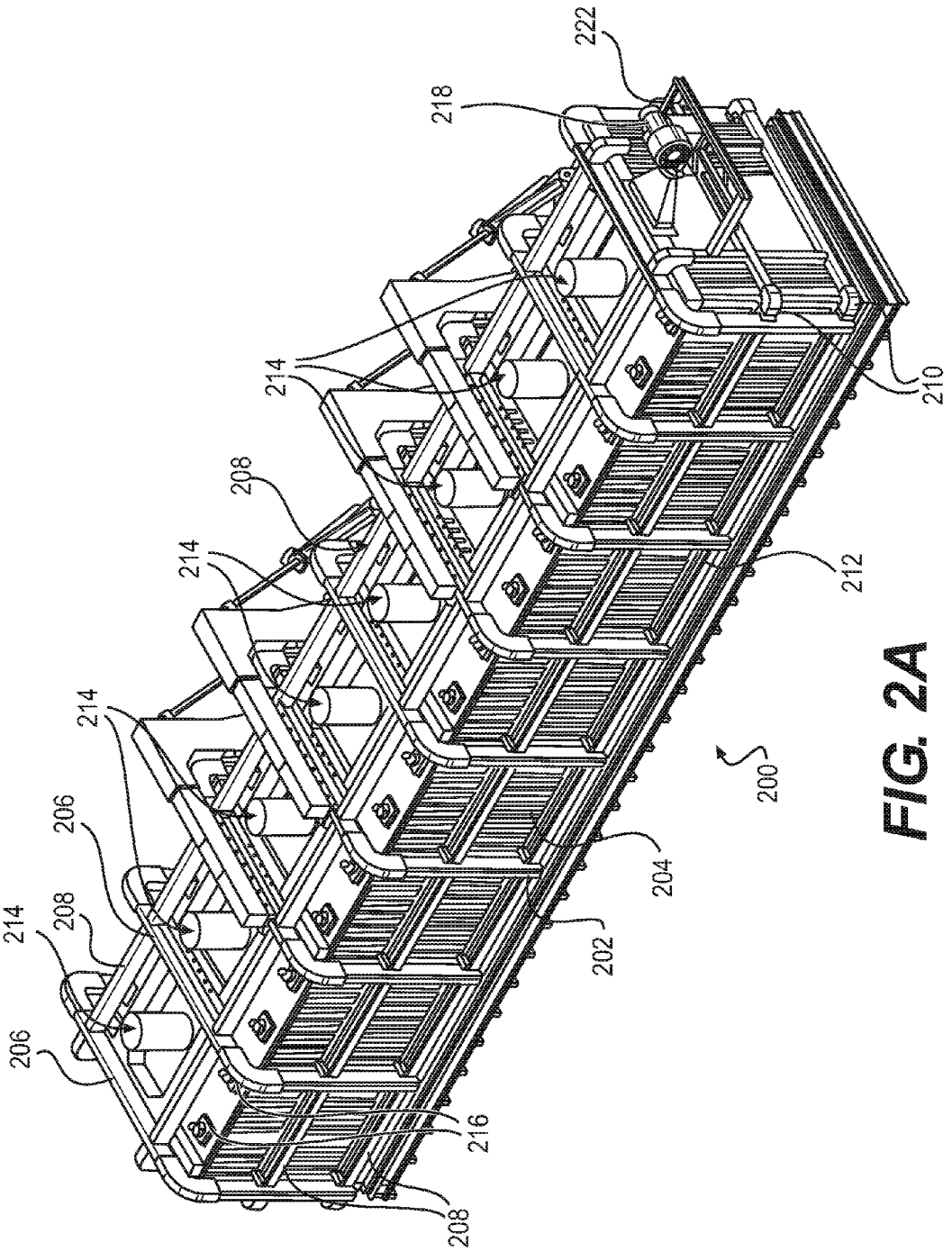

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FIG. 2A

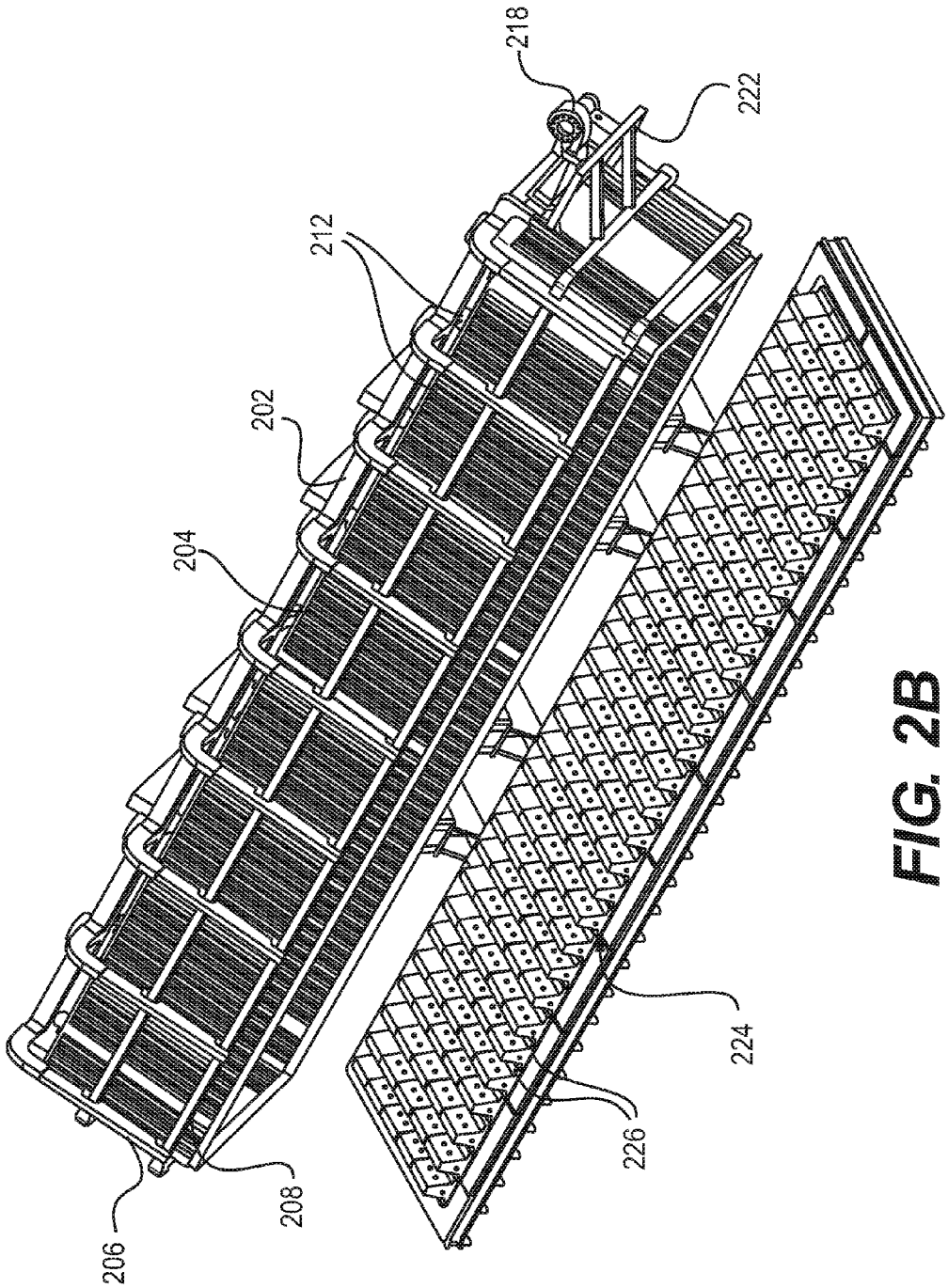

FIG. 2B

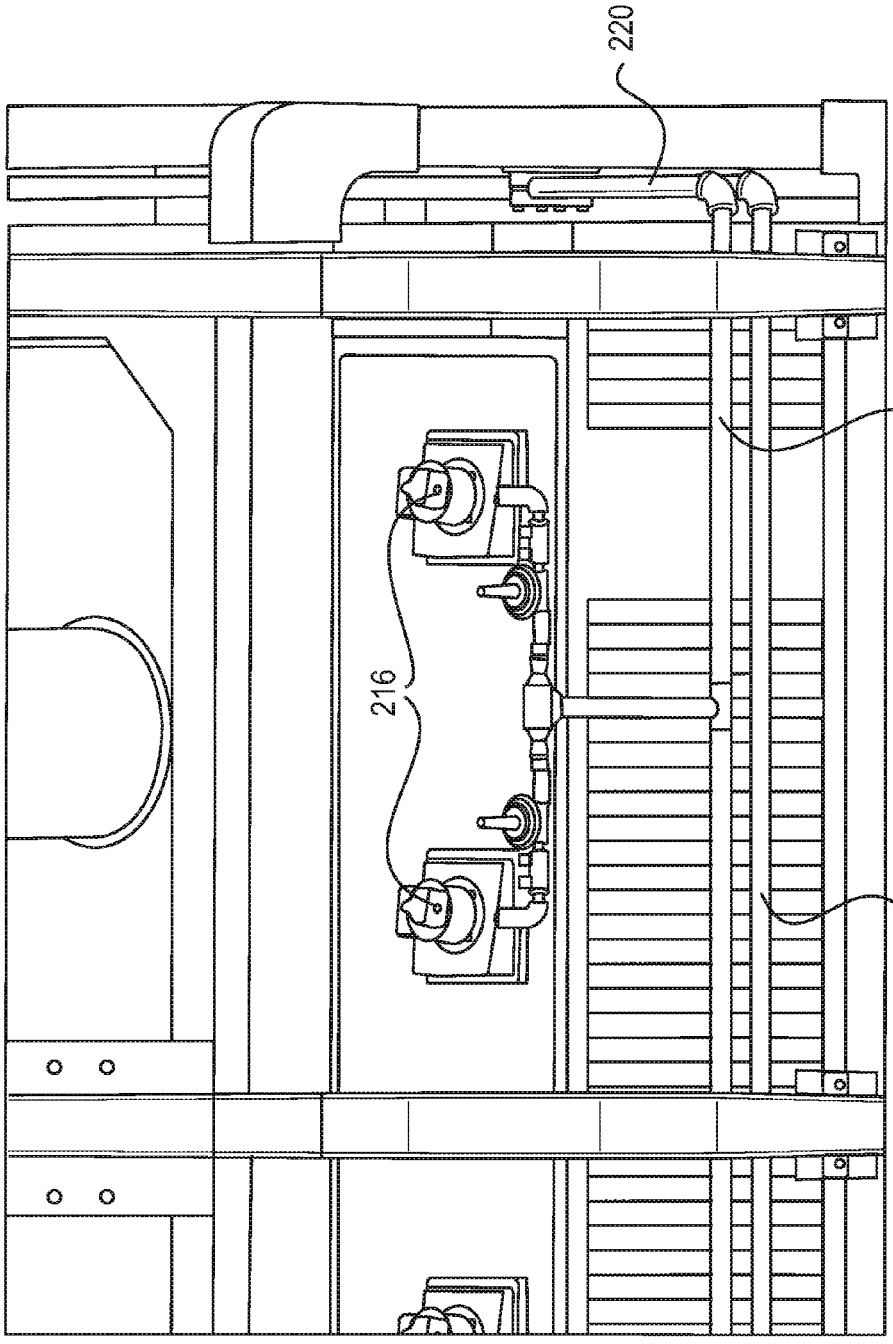

FIG. 2C

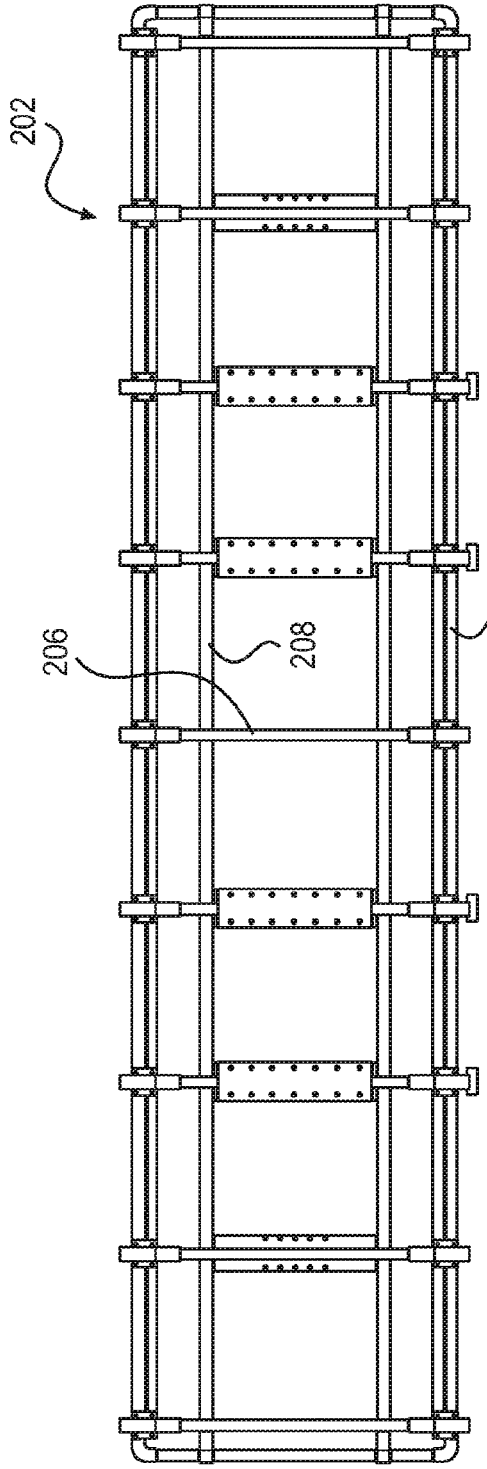

FIG. 2D

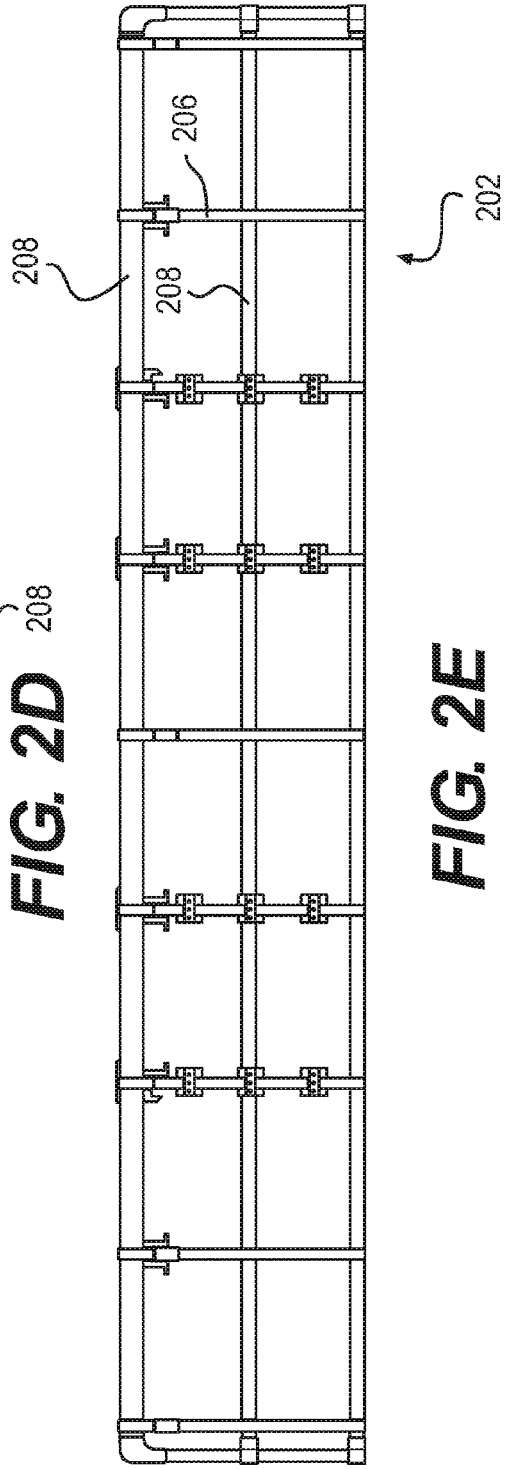

FIG. 2E

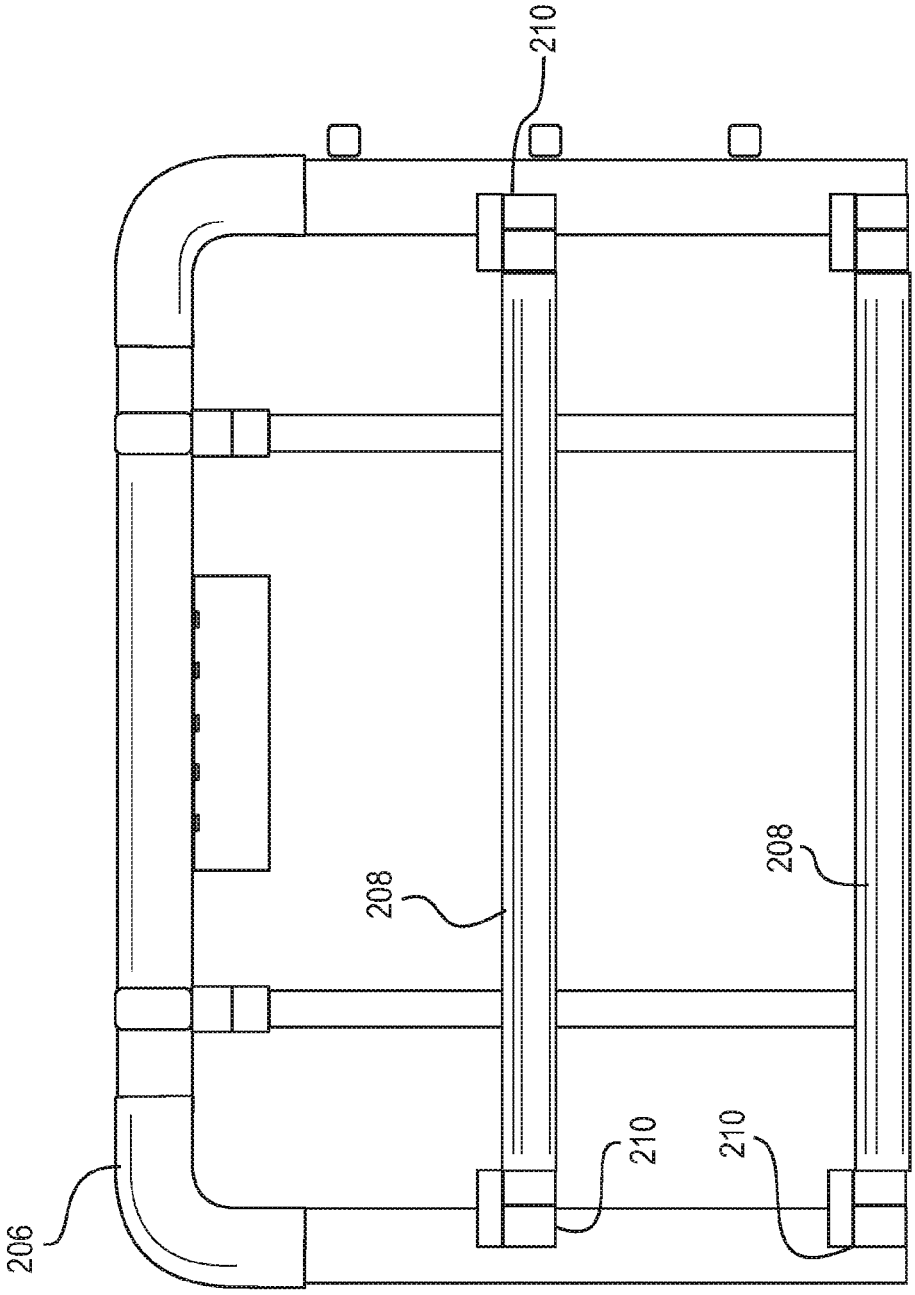

FIG. 2F

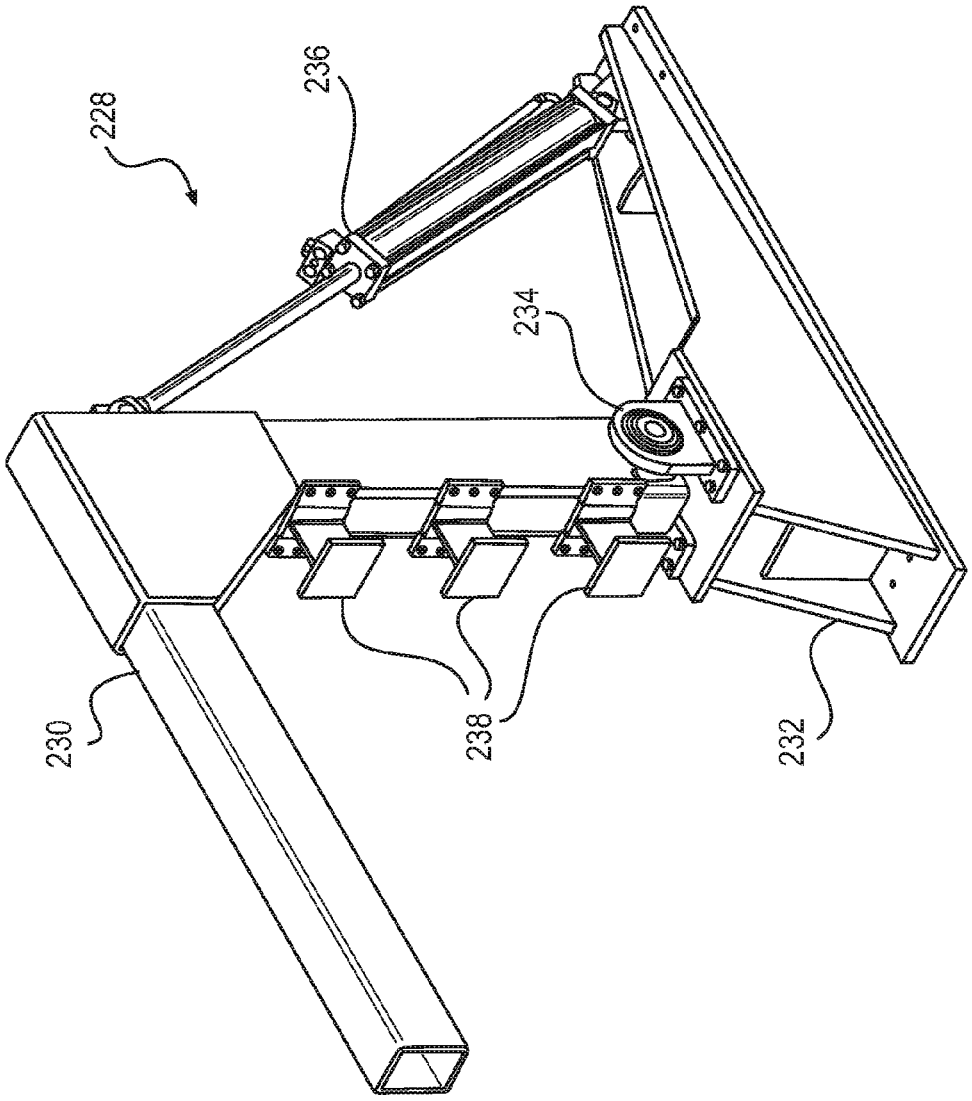

FIG. 2G

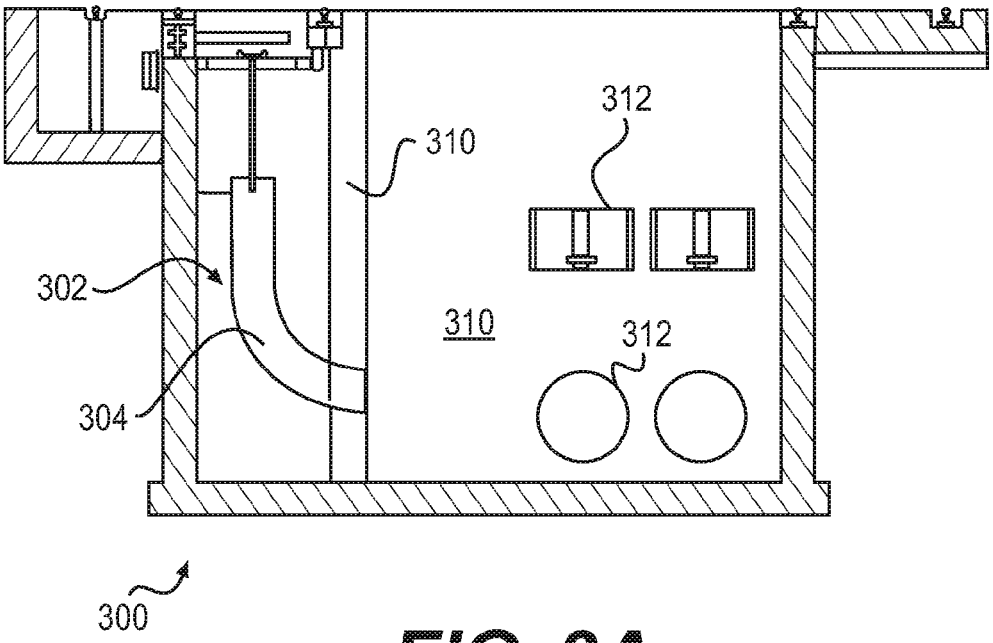

FIG. 3A

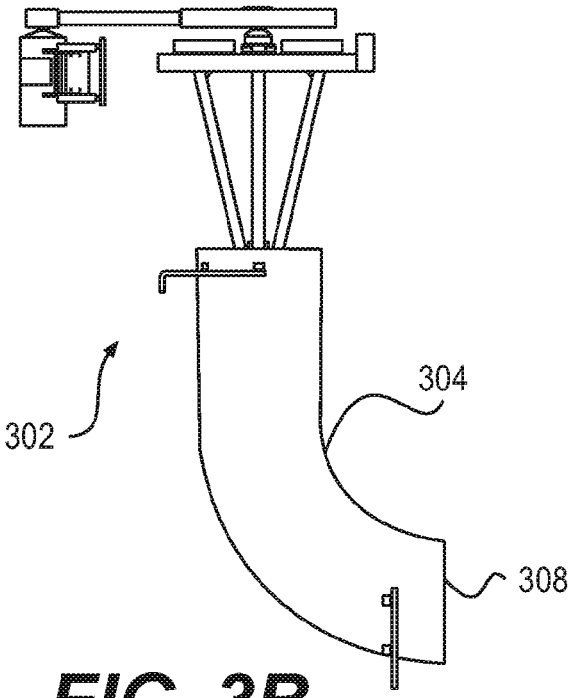

FIG. 3B

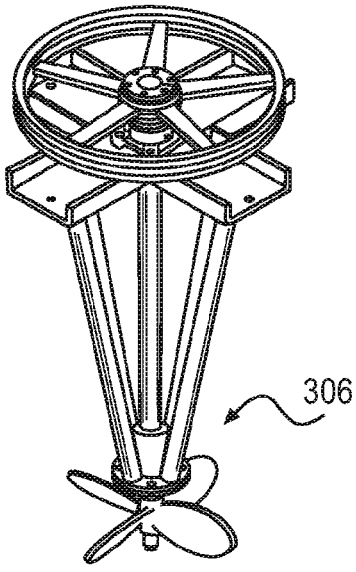

FIG. 3C

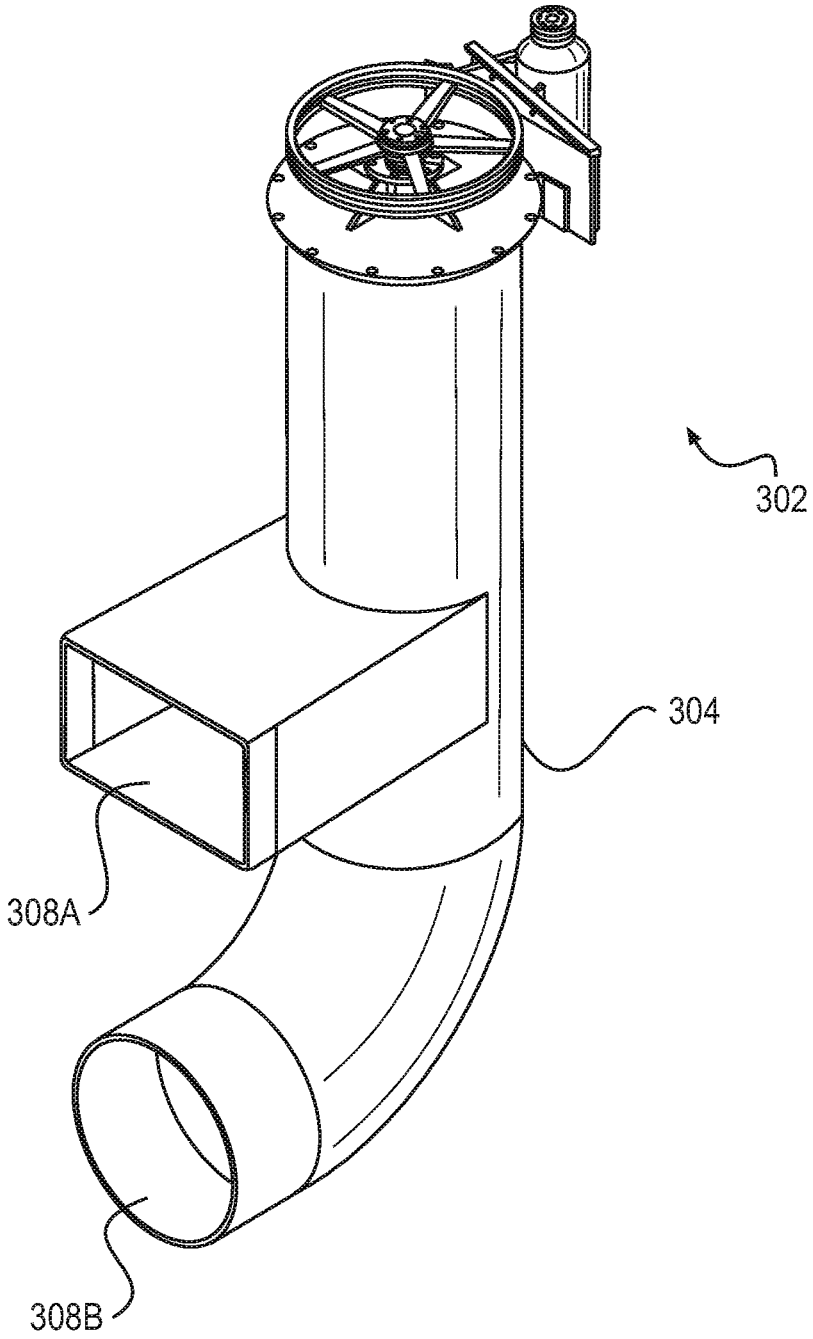

FIG. 3D

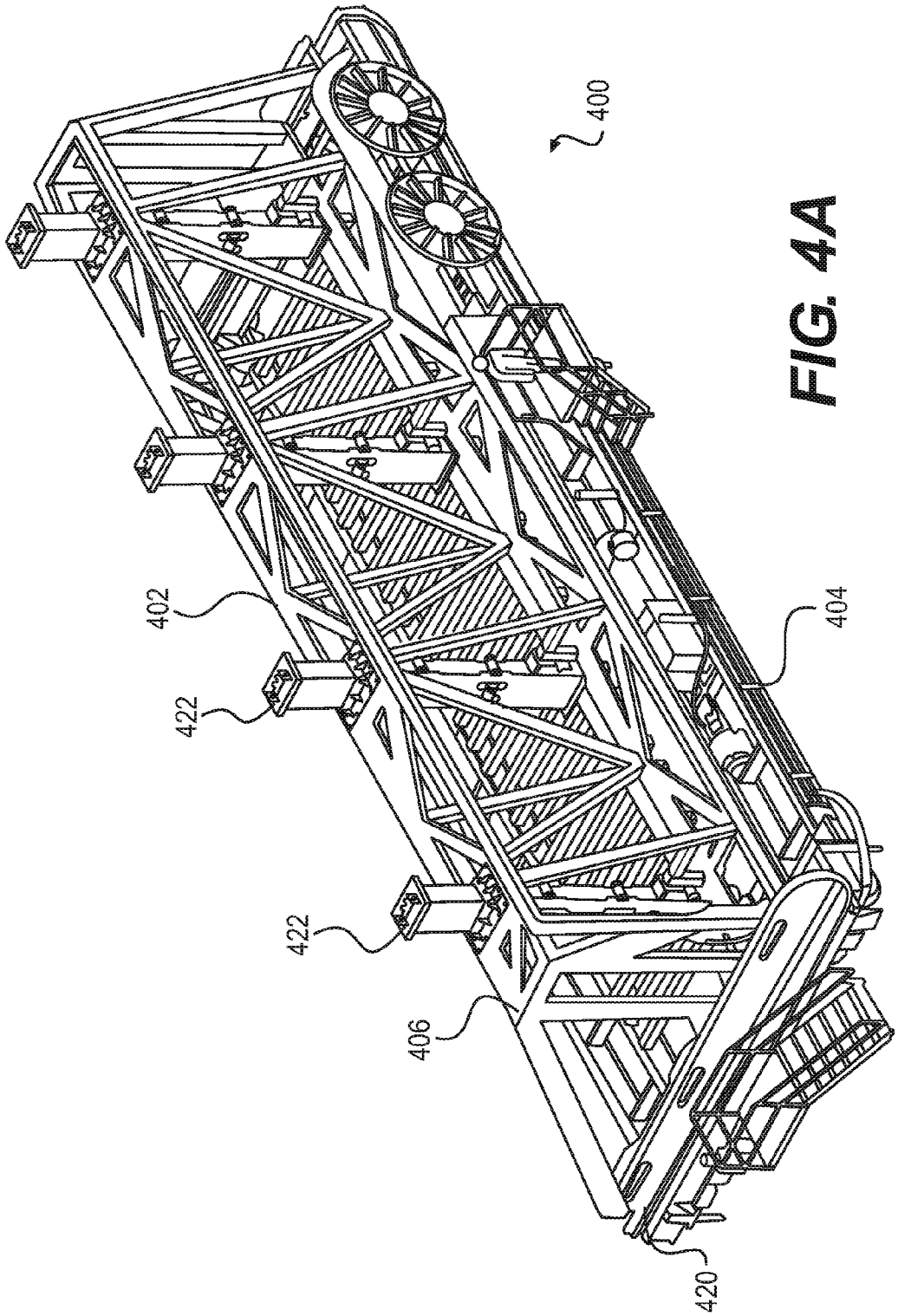

FIG. 4A

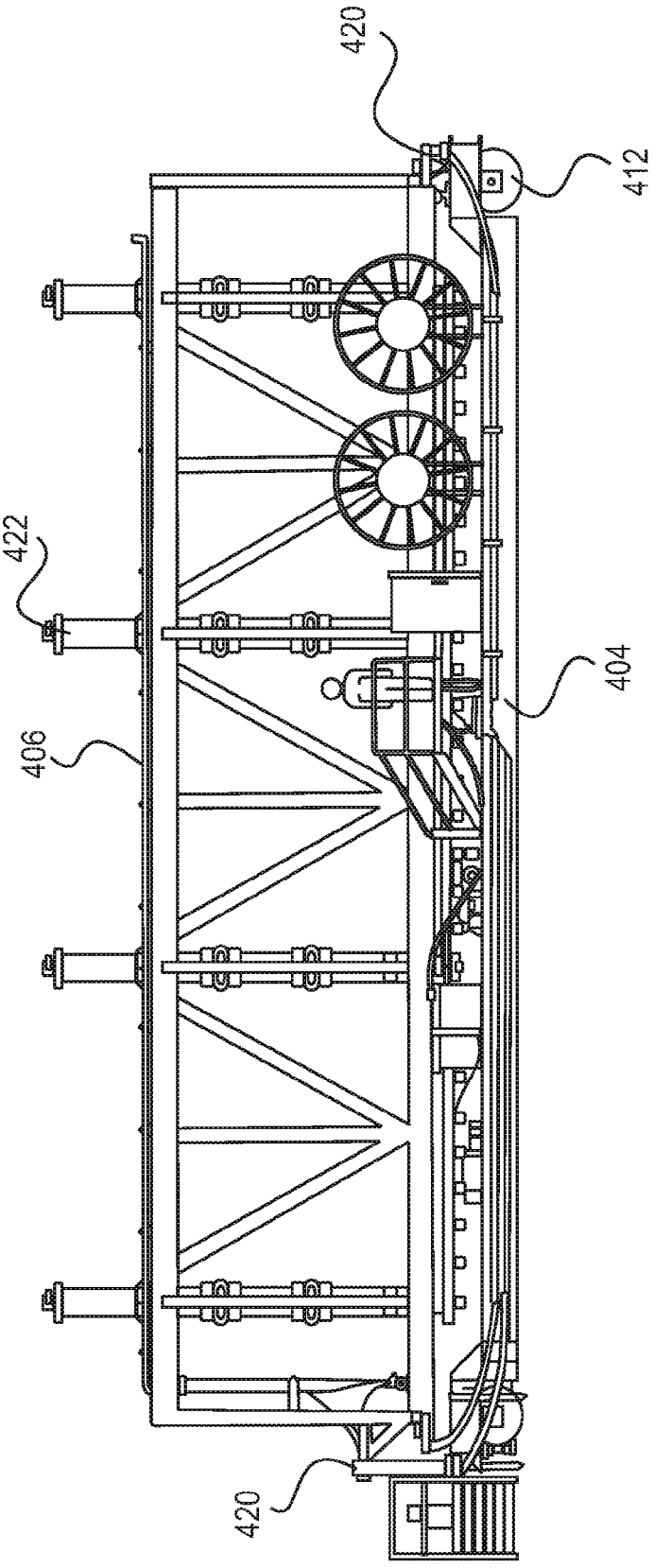

FIG. 4B

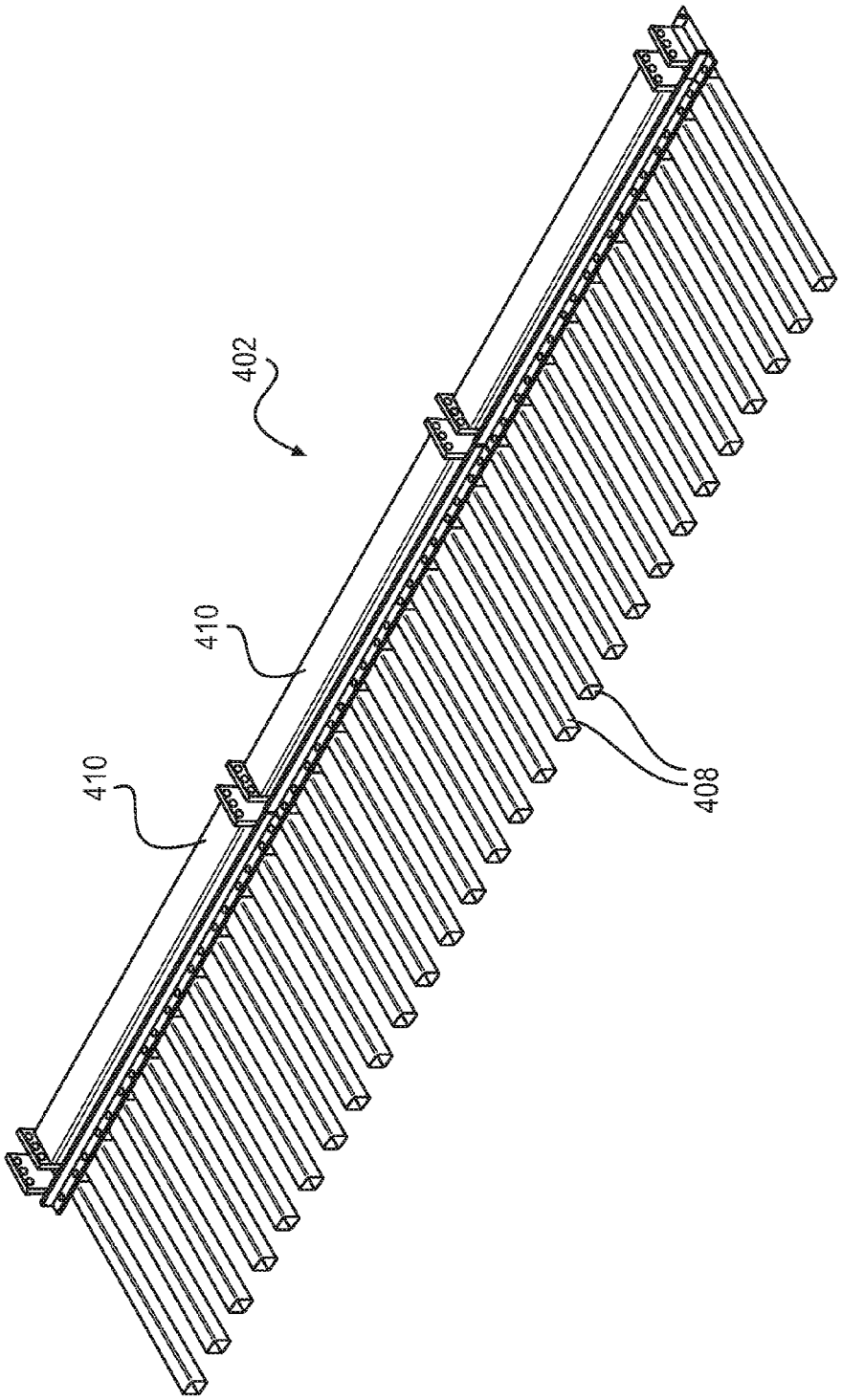

FIG. 4C

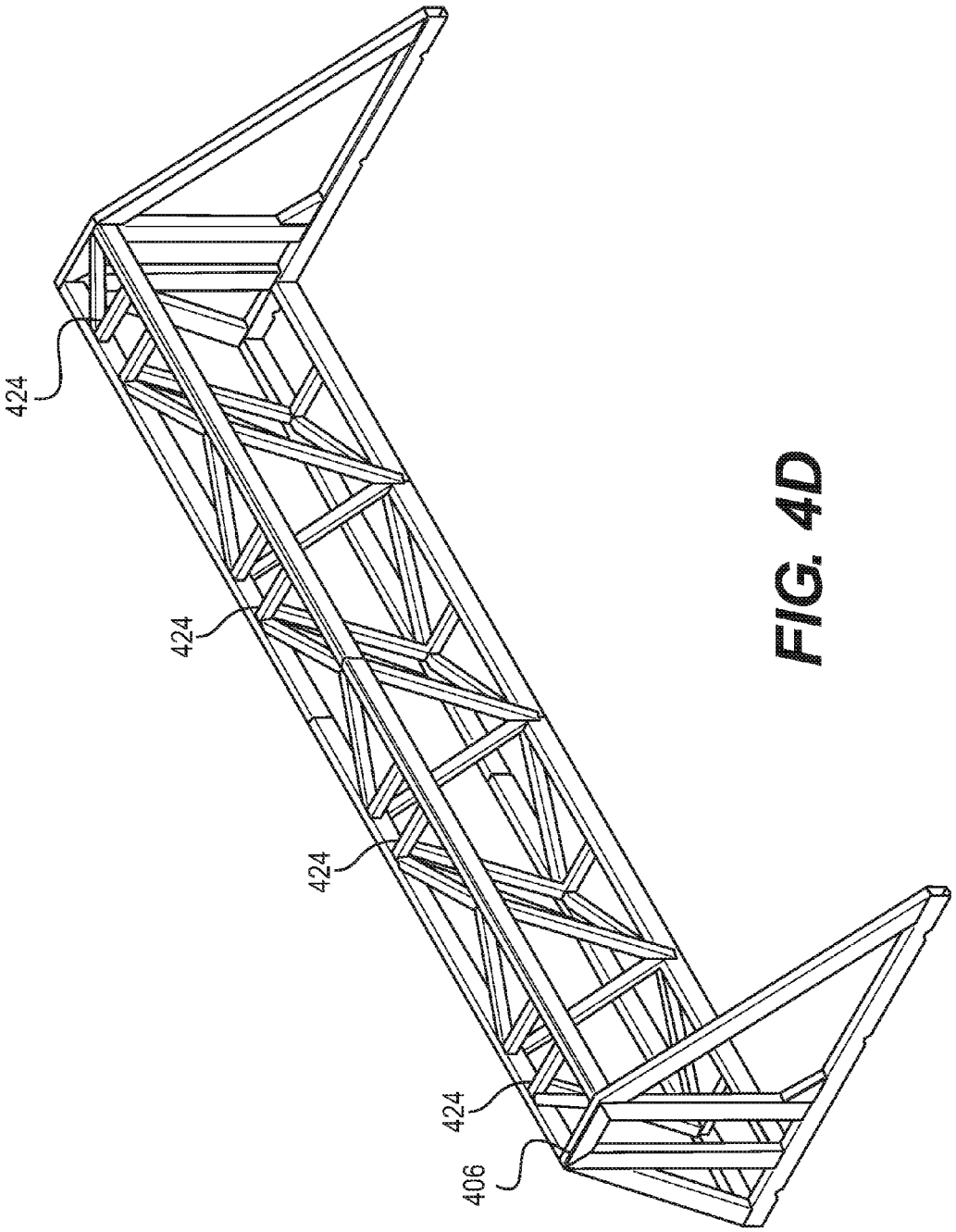

FIG. 4D

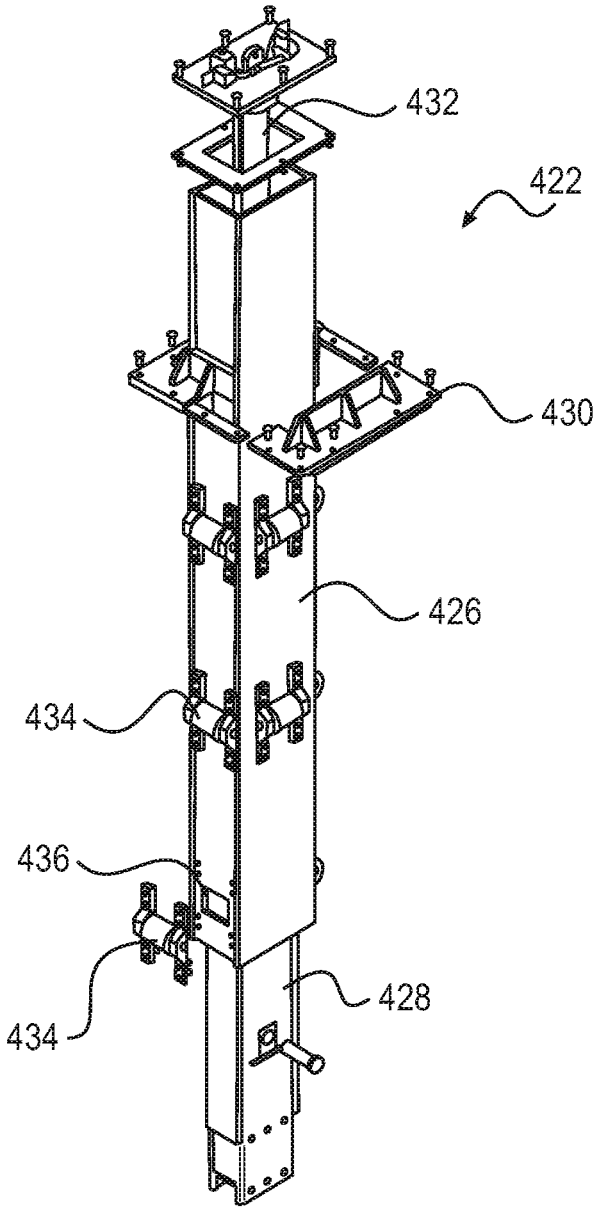

FIG. 4E

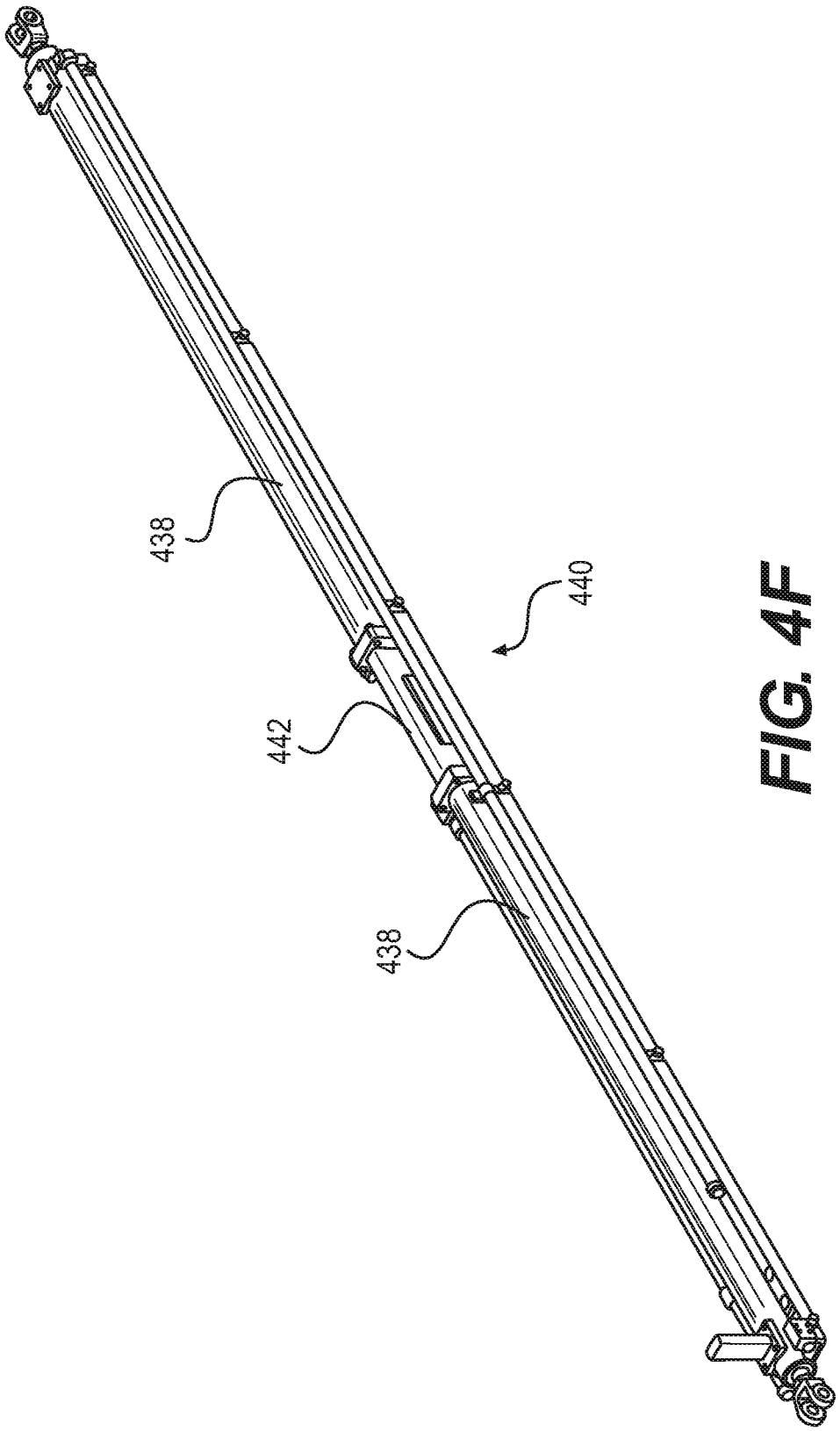

FIG. 4F

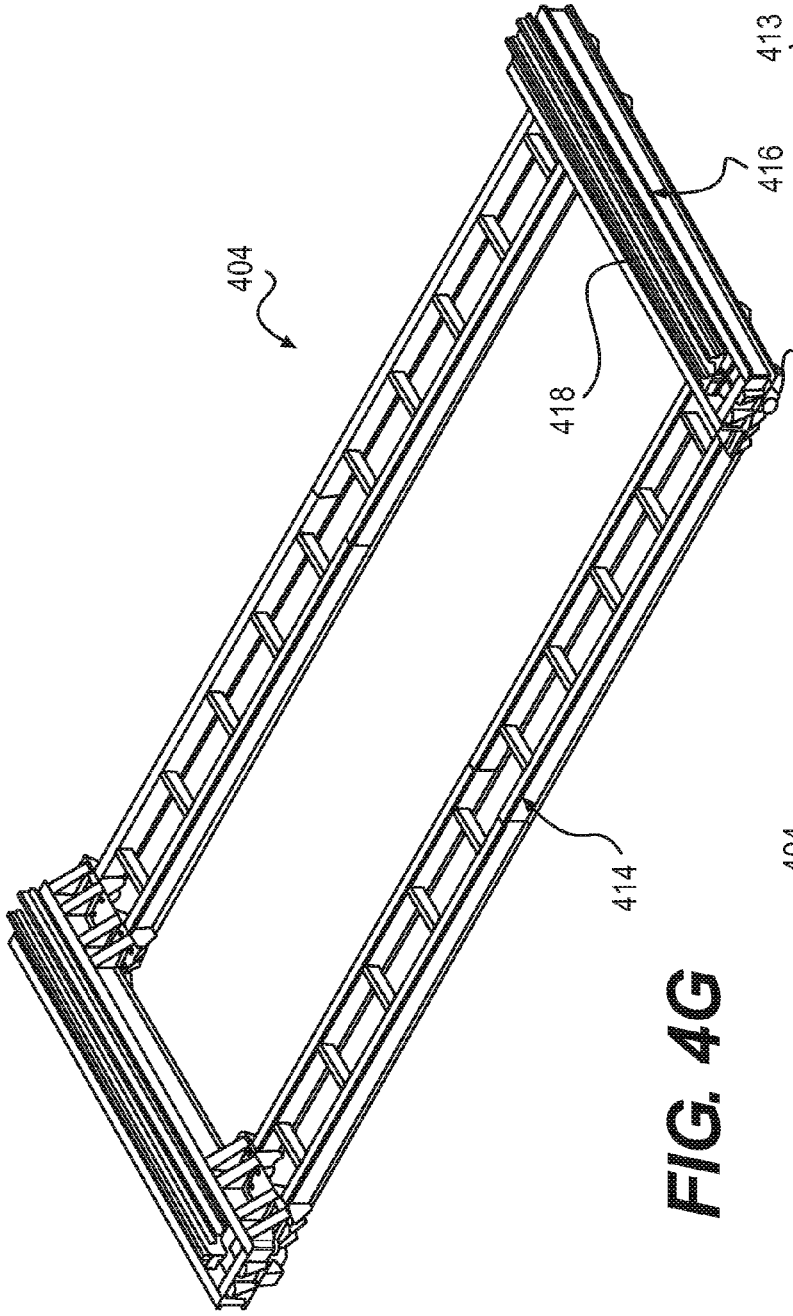

FIG. 4G

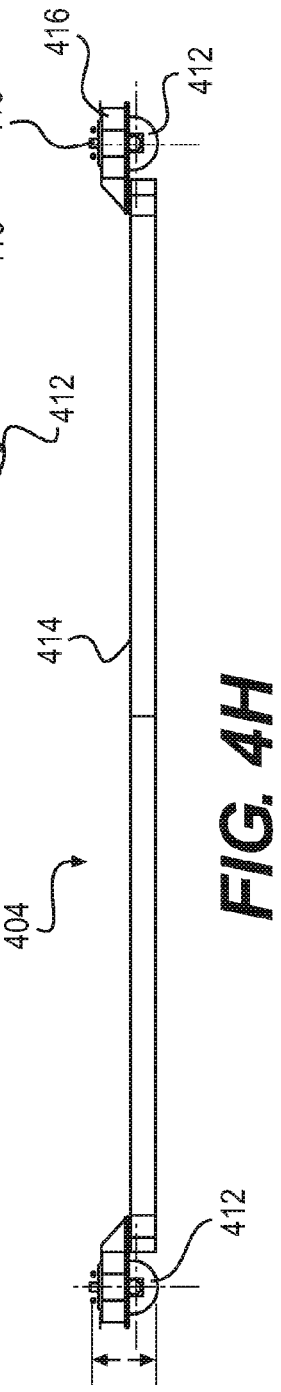

FIG. 4H

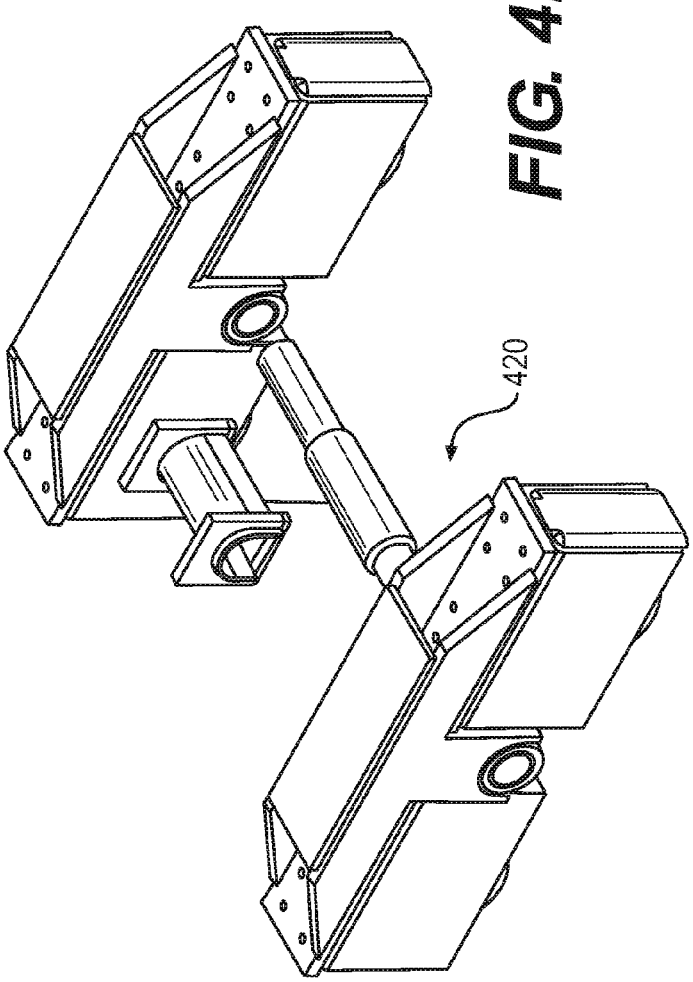

FIG. 4I

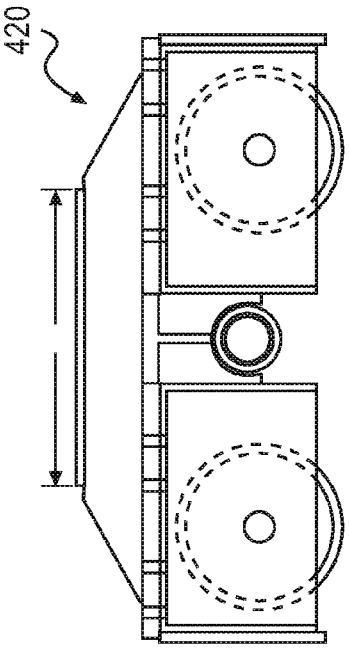

FIG. 4J

FURNACE AND SYSTEM FOR HEAT TREATING MATERIAL

BACKGROUND

The common approach for heat treating materials, such as metallic substances that include iron based alloys, is to place the material in or pass the material through a gas-fired furnace, or other form of ambient heating furnace or induction furnace that heats the material to the desired heat treatment temperature. As such, the materials may experience either a batch-type heat treatment process, in which the materials experience a stage-by-stage form of heat treatment, or a continuous-type heat treatment process, in which the materials experience a heat treatment process that includes a continuous motion for the materials to undergo different heat treatment techniques.

For example, when heat treating steel, the steel may be passed through or placed within a gas-fired or induction furnace for purposes of heating. The steel may then be removed from or exit the furnace to either be cooled or quenched according to various known techniques to achieve the desired physical properties in the steel depending upon whether the steel has been heated above or below its transformation temperature or selected critical temperatures thereof. However, very substantial capital investment is needed to provide a gas-fired furnace and other related equipment of the size that is capable of heat treating metallic tubular members, steel sheets, or the like. Further, the maintenance of such equipment may bring about other challenges to lengthen the life expectancy of such equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

For a detailed description of the preferred embodiments of the invention, reference will now be made to the accompanying drawings in which:

FIG. **1**A shows an above perspective view of a system for heat treating material as material is received upon a material loading station in accordance with one or more embodiments of the present disclosure;

FIG. **1**B shows an above perspective view of the system for heat treating material as material is received upon a manipulator assembly in accordance with one or more embodiments of the present disclosure;

FIG. **1**C shows an above perspective view of the system for heat treating material as material is transported by the manipulator assembly away from the material loading station in accordance with one or more embodiments of the present disclosure;

FIG. **1**D shows an above perspective view of the system for heat treating material as material is transported by the manipulator assembly towards the furnace in accordance with one or more embodiments of the present disclosure;

FIG. **1**E shows an above perspective view of the system for heat treating material as material is received from the manipulator assembly into the furnace in accordance with one or more embodiments of the present disclosure;

FIG. **1**F shows an above perspective view of the system for heat treating material as material heat treated within the furnace in accordance with one or more embodiments of the present disclosure;

FIG. **1**G shows an above perspective view of the system for heat treating material as material is received by the manipulator assembly from the furnace in accordance with one or more embodiments of the present disclosure;

FIG. **1**H shows an above perspective view of the system for heat treating material as material is positioned by the manipulator assembly above the quench tank in accordance with one or more embodiments of the present disclosure;

FIG. **1**I shows an above perspective view of the system for heat treating material as material is received from the manipulator assembly into the quench tank in accordance with one or more embodiments of the present disclosure;

FIG. **1**J shows an above perspective view of the system for heat treating material as material is transported by the manipulator assembly towards the material loading station in accordance with one or more embodiments of the present disclosure;

FIG. **1**K shows an above perspective view of the system for heat treating material as material is received from the manipulator assembly onto the material loading station in accordance with one or more embodiments of the present disclosure;

FIG. **1**L shows an above perspective view of a system for heat treating material as material that is heat treated is positioned upon the material loading station in accordance with one or more embodiments of the present disclosure;

FIG. **2**A shows an above perspective view of a furnace for heat treating material in a closed position in accordance with one or more embodiments of the present disclosure;

FIG. **2**B shows an above perspective view of the furnace for heat treating material in an open position in accordance with one or more embodiments of the present disclosure;

FIG. **2**C shows an above perspective view of the furnace for heat treating material including gas burners and tubing in accordance with one or more embodiments of the present disclosure;

FIG. **2**D shows an above perspective view of an outer support of the furnace for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. **2**E shows a side perspective view of an outer support of the furnace for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. **2**F shows an end perspective view of an outer support of the furnace for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. **2**G shows a perspective view of an arm assembly of the furnace for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. **3**A shows a cross-sectional view of a quench tank of a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. **3**B shows a perspective view of an agitator included within a quench tank of a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. **3**C shows a perspective view of an agitating mechanism included within a quench tank of a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. **3**D shows a perspective view of an agitator included within a quench tank of a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. **4**A shows an above perspective view of a manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. 4B shows a side view of a manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. 4C shows an above perspective view of a fork assembly of the manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. 4D shows an above perspective view of a carriage frame of the manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. 4E shows an above perspective view of a telescoping assembly of the manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. 4F shows an above perspective view of an actuator assembly of the manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. 4G shows an above perspective view of a transfer car of the manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. 4H shows a side view of a transfer car of the manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure;

FIG. 4I shows an above perspective view of a movement member of the manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure; and

FIG. 4J shows a side view of the movement member of the manipulator assembly from a system for heat treating material in accordance with one or more embodiments of the present disclosure.

DETAILED DESCRIPTION

The following discussion is directed to various embodiments of the invention. Certain features of the embodiments may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in the interest of clarity and conciseness. Although one or more of these embodiments may be preferred, the embodiments disclosed should not be interpreted, or otherwise used, as limiting the scope of the disclosure, including the claims. It is to be fully recognized that the different teachings of the embodiments discussed below may be employed separately or in any suitable combination to produce desired results. In addition, one skilled in the art will understand that the following description has broad application, and the discussion of any embodiment is meant only to be exemplary of that embodiment, and not intended to intimate that the scope of the disclosure, including the claims, is limited to that embodiment.

Certain terms are used throughout the following description and claims to refer to particular features or components. As one skilled in the art will appreciate, different persons may refer to the same feature or component by different names. This document does not intend to distinguish between components or features that differ in name but not structure or function. The drawing figures are not necessarily to scale. Certain features and components herein may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in interest of clarity and conciseness.

In the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to . . . . " Also, the term "couple" or "couples" is intended to mean either an indirect or direct connection. In addition, the terms "axial" and "axially" generally mean along or parallel to a central axis (e.g., central axis of a body or a port), while the terms "radial" and "radially" generally mean perpendicular to the central axis. The use of "top," "bottom," "above," "below," "higher," "lower," and variations of these terms is made for convenience, but does not require any particular orientation of the components.

One or more aspects of the present disclosure relate to a furnace, and a system including a furnace, for heat treating material. The furnace includes an outer support frame with an inner shell connected to and at least partially received within the outer support frame, in which the outer support frame and the inner shell movable to open and close to receive and remove material from the inner shell. The outer support frame may include rib assemblies and support members. The rib assemblies may each extend about at least a portion of the inner shell, with the support members connected across the rib assemblies to connect the rib assemblies to each other. The inner shell may include replaceable panels connected to each other and connected to the outer support frame, for example, such that the panels may be replaceable within the inner shell for maintenance. The inner shell may further include at least one exhaust flute operably coupled thereto, at least one gas burner operably coupled thereto, and at least one air blower operably coupled thereto. The furnace may further include at least one actuator and/or an arm assembly operably coupled thereto to open and close the outer support frame and the inner shell.

The system for heat treating material includes a furnace movable to open and close to receive and remove material therefrom, the furnace including an outer support frame and an inner shell connected thereto. The system further includes a quench tank to receive material therein, and a manipulator assembly to transport and move material between the furnace and the quench tank. The system may further include a material loading station, in which the manipulator assembly is configured to move between the furnace, the quench tank, and the material loading station.

The manipulator assembly may include a transfer car configured to move the manipulator assembly along a track between the furnace, the quench tank, and the material loading station, a fork assembly configured to receive and dispatch material from the manipulator assembly, and a carriage frame configured to movably couple the fork assembly to the transfer car. The manipulator assembly may further include at least one telescoping assembly coupled between the fork assembly and the carriage frame to move the fork assembly with respect to the carriage frame, such as to move the fork assembly vertically with respect to the carriage frame, and at least one actuator coupled between the carriage frame and the transfer car to move the carriage frame with respect to the transfer car, such as to move the carriage frame horizontally with respect to the transfer car.

Further, the quench tank may include agitators. At least one of the agitators may include multiple ports, and at least one of the agitators may be positioned at an end of the quench tank. Furthermore, in accordance with one or more embodiments of the present disclosure, the furnace and the system may be capable of heat treating material, such as a tubular member, having a length between about 25 feet (about 7.6 meters) and about 55 feet (about 16.8 meters).

Referring now to FIGS. **1**A-**1**L, multiple perspective views of a system **100** for heat treating material **102** in accordance with one or more embodiments of the present disclosure are shown. In particular, FIGS. **1**A-**1**L show a method of operation of the system **100**, such as when heat treating the material **102** in accordance with a method of the present disclosure. The system **100** includes a furnace **104**, a quench tank **106**, and a manipulator assembly **108**. The system **100** may further include a material loading station **110**.

The furnace **104** may be able to apply heat to the material **102** during the heat treatment process, and therefore the furnace **104** is able to open and close to receive and remove the material **102** therefrom. The quench tank **106** may be used for quenching, or rapidly cooling, the material **102**, and therefore the quench tank **106** may be used to retain a quenching medium therein, such as water, polymer, oil, and/or other quenching medium known in the art, to receive the material **102** when quenching. The material loading station **110**, if included, may be used to receive the material **102** within the system **100**, such as before the heat treatment of the material **102**, and may be used to receive the material **102** also after heat treatment through the system **100**. Further, the manipulator assembly **108** may be used to transport and move the material **102** between the different stations and points within the system **100**. As such, the manipulator assembly **108** may be able to receive and dispatch the material **102**, may be able to move between the furnace **104**, the quench tank **106**, and the material loading station **110**, and may be able to raise and lower the material **102** as necessary within the system **100**.

As shown in FIG. **1**A, the material **102** may be initially delivered or set on the material loading station **110**. The material loading station **110** may include a heat-resistant surface **112**, such as a surface formed of or including hearth and/or other heat-resistant or heat-tolerant material, in which the heat-resistant surface **112** that includes one or more ridges **114** formed therein.

As shown between FIGS. **1**A, **1**B, and **1**C, the manipulator assembly **108** may move from a rest position to then interact with the material loading **110** to receive the material **102** onto the manipulator assembly **108** from the material loading station **110**. The ridges **114** may be included within the material loading station **110** to enable the manipulator assembly **108** to receive the material from the loading station **110**, such as by having a fork assembly (discussed more below) of the manipulator assembly **108** enter into the ridges **114** from a side of the material loading station **110** and then lift from underneath the material **102** to receive the material **102** into the manipulator assembly **108**.

As shown in FIG. **1**D, the manipulator assembly **108** may move away from the material loading station **110** with the material **102** received thereupon, in which the manipulator assembly **108** may then move, such as along tracks **116**, to be adjacent the furnace **104**. The furnace **104** may then open, as shown in FIG. **1**E, to receive the material **104** from the manipulator assembly **108**. As such, the furnace **104** may include a heat-resistant surface **118**, such as a surface formed of or including hearth and/or other heat-resistant or heat-tolerant material. The heat-resistant surface **118** may include one or more ridges formed therein, such as to facilitate receiving and removing the material **102** for the furnace **104**. Further, though only a bottom surface is shown as the heat resistant surface **118**, the furnace **104** may include other heat resistant surfaces, such as one or more of the side surfaces or the upper surface, to facilitate heating the material **102** within the furnace **104**. Accordingly, as shown in FIG. **1**F, the furnace **104** may close to heat the material **102** to a desired temperature for a desired amount of time. Upon completion of the heating of the material **102**, the furnace **104** may then open again, as shown in FIG. **1**G, in which the manipulator assembly **108** may move to interact with the furnace **104** again to receive the material **102** onto the manipulator assembly **108**.

As shown in FIGS. **1**H and **1**I, after the material **102** has been heated within the furnace **104**, the material **102** may be moved adjacent the quench tank **106** for quenching. In particular, as shown, the manipulator assembly **108** may move over the quench tank **106**, in which the manipulator assembly **108** may lower the material **102**, such as by lowering the fork assembly of the manipulator assembly **108** supporting the material **102**, into the quench tank **106**. As such, the quench tank **106** may be used to cool the material **102** therein within a desired quenching medium at a desired temperature for a desired amount of time. Upon completion of quenching of the material **102**, the manipulator assembly **108** may raise the material **102**, such as by raising the fork assembly of the manipulator assembly **108** supporting the material **102**, from the quench tank **106**.

Depending on the desired characteristics for the material **102**, the material **102** may receive additional heating, quenching, and/or cooling. For example, the system **100** may repeat heating the material **102** within the furnace **104** and quenching the material within the quench tank **106**, as shown in FIGS. **1**D-**1**J. Upon completion of the heating and quenching of the material **102**, as shown in FIGS. **1**J, **1**K, and **1**L, the manipulator assembly **108** may then move away from the quench tank **106** to return the material **102** to the material loading station **110**, such as for additional cooling and/or to have the material **102** collected for distribution and/or other post heat treatment processes.

Referring now to FIGS. **2**A-**2**F, multiple views of a furnace **200** and components thereof in accordance with one or more embodiments of the present disclosure are shown. As discussed above, the furnace **200** may be movable to open and close to receive and remove material therefrom for heating. Accordingly, FIG. **2**A shows the furnace **200** in the closed position, and FIG. **2**B shows the furnace **200** in the open position.

The furnace **200** may include an outer support frame **202** with an inner shell **204** connected to the outer support frame **202**. The inner shell **204** may also be received, such as at least partially received, within the outer support frame **202** such that the outer support frame **202** supports and reinforces the inner shell **204**. FIGS. **2**D, **2**E, and **2**F show multiple views of the outer support frame **202**. As shown, the outer support frame **202** may include rib assemblies **206** and support members **208**. The rib assemblies **206** may be arranged along the length of the inner shell **204** of the furnace **200**, such as equally spaced therealong, with the rib assemblies **206** extending about and around the inner shell **204**. For example, though the present disclosure is not so limited, the rib assemblies **206** are shown as extending about and around three sides of the inner shell **204**. The support members **208** may then be connected across and between the rib assemblies **206**, thereby connecting the rib assemblies **206** to each other to form the outer support frame **202**. The support members **208** may extend across side surfaces and/or the top surface of the inner shell **204**, as shown, to connect adjacent rib assemblies **206**. Further, in one or more embodiments, the rib assemblies **206** may have one or more recesses **210** formed therein. As such, one or more of the support members **208** may connect, directly or indirectly, to

the recesses **210** such that the support members **208** may be supported from the recesses **210** of the rib assemblies **206**.

With reference to FIGS. **2**A, **2**B, and **2**C, the inner shell **204** of the furnace **200** may include and/or be formed from replaceable panels **212**. The panels **212** may be connected to each other, such as through connection members (e.g., bolts) and/or welding, and the panels **212** may also be connected to the outer support frame **202**. For example, each of the panels **212** may be connected to adjacent panels **212**, with only some of the panels **212** connected to the outer support frame **202** such that the outer support frame **202** supports the panels **212** of the inner shell **204**. As the panels **212** of the inner shell **204** are supported by the outer support frame **202**, the panels **212** may be replaced without sacrificing the structural integrity of the inner shell **204**. For example, individual panels **212** may be replaceable, as needed, based upon use and wear, such as by having the damaged panels **212** cut away or unhinged and replaced with undamaged panels **212**. During this replacement process, the inner shell **204** may distort and/or warp. Accordingly, the outer support frame **202** may provide additional structural support to the inner shell **204** to assist in the maintenance process of the furnace **200**.

In addition to the outer support frame **202** and the inner shell **204**, the furnace **200** may include one or more components included therein and/or operably coupled thereto. For example, with reference to FIGS. **2**A, **2**B, and **2**C, the furnace **200** may include one or more exhaust flutes **214**, one or more gas burners **216**, and/or one or more air blowers **218**. The gas burners **216** may be operably coupled and connected to the inner shell **204** of the furnace **202**. As such, the gas burners **216** may be used to supply heat to the interior of the furnace **200**, such as when heating material within the furnace **200**. Further, the exhaust flutes **214** may be operably coupled and connected to the inner shell **204** of the furnace **202**, such that gas, fumes, and/or other products from the interior of the furnace **200** may released through the exhaust flutes **214**, as desired. One or more lines of tubing **220** may be used to provide gas to the gas burners **216**. As such, and as shown particularly in FIG. **2**C, the tubing **220** may be connected to and supported from the outer support frame **202**.

Furthermore, the air blower **218** may be operably coupled and connected to the inner shell **204** of the furnace **200** such that air may be introduced from the exterior of the furnace **200** into the interior of the furnace **200**. As shown in FIG. **2**A in particular, a support base **222** may be used to support the air blower **218**, in which the support base **222** may be connected to and extend from the outer support frame **202** of the furnace **200**. Accordingly, the exhaust flutes **214**, the gas burners **216**, and/or the air blower **218** may be included within the furnace **200** to adequately control the temperature and heat differential within the furnace **200**, as desired, such as when heating material within the furnace **200**.

As discussed above, a furnace in accordance with the present disclosure may include one or more heat-resistant surfaces. As such, with respect to FIG. **2**B, the furnace **200** may include a heat-resistant surface **224**, such as a surface formed of or including hearth and/or other heat-resistant or heat-tolerant material. The heat-resistant surface **224** may include one or more ridges **226** formed therein, such as to facilitate receiving and removing material for the heat-resistant surface **224**. Further, though only a bottom surface is shown as the heat resistant surface **224**, the furnace **200** may include other heat resistant surfaces, such as one or more of the side surfaces or the upper surface, to facilitate heating material within the furnace **200**.

To facilitate opening and closing the furnace **200**, the furnace **200** may have one or more actuators and/or one or more arm assemblies operably coupled to the furnace **200**. For example, with reference to FIG. **2**G, an arm assembly **228** in accordance with the present disclosure is shown. The arm assembly **228** may include an arm **230** that connects to a base **232**, in which the arm **230** may rotate about a hinge **234** with respect to the base **232**. Further, the arm assembly **228** may include an actuator **236**, such as a hydraulic actuator (e.g., cylinder), in which the actuator **236** is shown as connected between the arm **230** and the base **232** to control movement of the arm **230** with respect to the base **232**. The arm assembly **228** may have one or more connection points **238**, such as to connect to the outer support frame **202** of the furnace **200**. In particular, as shown in FIG. **2**A, the arm assembly **228** may connect to the top surface and/or one or more side surfaces of the outer support frame **202**. Further, as shown, multiple arm assemblies **228** may be connected to the furnace **200** to facilitate opening and closing.

With respect to the above figures, the furnace **200** is shown to open and close by using a clamshell type action, in which the furnace **200** rotates about an axis of an offset hinge to move between the open and closed positions. However, the present disclosure is not so limited, as other types of action may be used to open and close a furnace without departing from the present disclosure. Further, though a hydraulic actuator is shown and discussed above, the present disclosure is not so limited, as other actuators, such as a pneumatic, electric, and/or mechanical actuator may be used without departing from the present disclosure. Further, those having ordinary skill in the art will appreciate that the present disclosure contemplates other arrangements and configurations for an arm assembly without departing from the present disclosure. For example, in one or more embodiments, a torque tube may be included within or between one or more arm assemblies, in which torque may be applied through the tube to the move the arm assemblies and the furnace between the open and closed positions. Accordingly, the present disclosure contemplates other embodiments than those specifically discussed or shown with respect to the above figures.

Referring now to FIGS. **3**A-**3**D, multiple views of a quench tank **300** and components thereof in accordance with one or more embodiments of the present disclosure are shown. As discussed above, the quench tank **300** may include one or more agitators **302**, such as to agitate the quenching medium included within the quench tank **300**, particularly when material is within the quench tank **300** for quenching and cooling. As shown in FIGS. **1**A-**1**L, one or more of the agitators **302** may be positioned along the length of the quench tank **300**, and one or more of the agitators **302** may be positioned at one or both of the ends of the quench tank **300**. For example, as the quench tank **300** may have a rectangular shape, such as when viewed from above in the embodiment shown in FIGS. **1**A-**1**L, the quench tank **300** may have two longer sides and two shorter ends. In such an embodiment, one or more of the agitators **302** may be positioned along the length of the quench tank **300**, and one or more of the agitators **302** may be positioned at one or both of the ends of the quench tank **300**.

As shown in FIGS. **3**B-**3**D, the agitator **302** may include a conduit **304** with an agitating mechanism **306**, such as a propeller shown in FIG. **3**C, included within the conduit **304**. The conduit **304**, which may be a J-tube, may include one or more ports **308**, such as a single port **308** shown in FIG. **3**B, or multiple ports **308** shown in FIG. **3**D. In FIG.

3D, the conduit **304** of the agitator **302** is shown as having an upper port **308**A and a lower port **308**B, though other arrangements and configurations, such as side-by-side ports, may be used without departing from the scope of the present disclosure.

The quench tank **300** may further include one or more partitions **310** formed therein, such as positioned along the length of the quench tank **300** and/or at the ends of the quench tank **300**. Accordingly, the partitions **310** may be used to support and/or protect the agitators **302**. For example, the partitions **310** may have one or more windows **312** formed therein, such as corresponding to the location of the ports **308** of the agitators **302**. As such, portions of the conduits **304** may be received within and/or extend through the windows **312** such that the ports **308** of the agitators **302** are able to agitate and expel fluid through the windows **312** of the partitions **310**.

Referring now to FIGS. **4**A-**4**J, multiple views of a manipulator assembly **400** and components thereof in accordance with one or more embodiments of the present disclosure are shown. As discussed above, the manipulator assembly **400** may be used to move material between different stations and points within a system for heat treating material in accordance with one or more embodiments of the present disclosure. As such, amongst other functions, the manipulator assembly **400** may be able to: move between a furnace, a quench tank, and/or a material loading station within the system; receive and dispatch material, such as from and into the furnace and/or the material loading station; and/or raise and lower material as desired within the system.

The manipulator assembly **400** may include one or more components to enable movement, such as to enable horizontal and/or vertical movement of material within the system with the manipulator assembly **400**. As such, the manipulator assembly **400** may include a fork assembly **402**, a transfer car **404**, and/or a carriage frame **406**. The fork assembly **402**, as shown particularly in FIG. **4**C, may be used to receive material into and dispatch material from the manipulator assembly **400**. The fork assembly **402** may include one or more forks **408** and one or more base support members **410**. The forks **408** may be connected to and extend from the base support members **410**. In one or more embodiments, during use within a system of the present disclosure, the forks **408** of the fork assembly **402** may enter into the ridges of a heat-resistant surface, such as the heat-resistant surface **112** of the material loading station **110** or the heat-resistant surface **118** of the furnace **104**, and lift from underneath the material to receive material from the material loading station and/or the furnace. As such, in one or more embodiments, the forks **408** may extend horizontally from the base support members **410** within the fork assembly **402**, in which the fork assembly **402** may be able to move vertically within the manipulator assembly **400**, such as to receive and dispatch material.

The transfer car **404** may be used to move the manipulator assembly **400** within the system, such as move the manipulator assembly **400** between the furnace, the quench tank, and/or the loading station. For example, in an embodiment in which the system **100** includes tracks **116**, as shown in FIG. **1**A, the transfer car **404** may be able to move the manipulator assembly **400** along the tracks of the system. As such, and as shown in FIGS. **4**G and **4**H, the transfer car **404** may include one or more movement members **412**, such as wheels in this embodiment, or anything other type of member known in the art, that may enable movement of the transfer car **404** and the manipulator assembly **400**. The transfer car **404** may further include one or more base members **414** and one or more support members **416** connected to the base members **414**. As shown in this embodiment, the movement members **412** may be connected to the support members **416**, with the base members **414** extending between and connecting the support members **416**.

Further, the carriage frame **406** may be used to support the fork assembly **402** and/or may be used to movably couple the fork assembly **402** to the transfer car **404**. A detailed view of the carriage frame **406** is shown in FIG. **4**D. As such, in one or more embodiments, the transfer car **404** may have tracks **418** included therewith and/or connected thereto, such as to enable movement of the fork assembly **402** and/or the carriage frame **406** with respect to the transfer car **404**. As shown in FIGS. **4**G and **4**H, the tracks **418** may be positioned on and connected to the support members **416** of the transfer car **404**, in which the fork assembly **402** and/or the carriage frame **406** may be able to move along the tracks **418**. One or more movement members **420**, such as a wheel assembly shown in FIGS. **4**I and **4**J, may then be positioned between the transfer car **404** and the fork assembly **402** and/or the carriage frame **406**. As shown in FIGS. **4**A and **4**B, the movement members **420** may be positioned between the carriage frame **406** and the transfer car **404** to enable movement (e.g., horizontal movement) of the carriage frame **406** along the tracks **418** with respect to the transfer car **404**. As the carriage frame **406** may be used to support the fork assembly **402**, the fork assembly **402** may also be movable, such as in the horizontal direction, with respect to the transfer car **404**.

As mentioned, the fork assembly **402** may be movable with respect to the transfer car **404**, such as horizontally and/or vertically movable with respect to the transfer car **404**. Accordingly, as the carriage frame **406** may be used to support the fork assembly **402** and/or may be used to movably couple the fork assembly **402** to the transfer car **404**, the carriage frame **406** may include one or more actuators and/or other components to enable movement of the fork assembly **402** with respect to the carriage frame **406** and/or the carriage frame **406** with respect to the transfer car **404**.

In one or more embodiments, one or more telescoping assemblies **422** may be coupled between the fork assembly **402** and the carriage frame **406** to move the fork assembly **402** with respect to the carriage frame **406**, such as vertically move the fork assembly **402** with respect to the carriage frame **406**. The carriage frame **406** may include one or more openings **424** formed therein to receive the telescoping assemblies **422** within the carriage frame **406**. As such, the telescoping assemblies **422** may be positioned and inserted within the openings **424** to couple between the fork assembly **402** and the carriage frame **406**.

A detailed view of the telescoping assembly **422** is shown in FIG. **4**E. The telescoping assembly **422** may include an outer member **426** and an inner member **428** movably received within the outer member **426**. An actuator **432** may then be positioned within the telescoping assembly **422** and connected between the outer member **426** and the inner member **428** to move the outer member **426** and the inner member **428** with respect to each other. In this embodiment, the outer member **426** is shown as an upper member, and the inner member **428** is shown as a lower member, though the present disclosure is not so limited. As such, in this embodiment, the outer member **426** may be coupled to the carriage frame **406**, and the inner member **428** may be coupled to the fork assembly **402**. Accordingly, a support bracket **430** may be included with the telescoping assembly **422**, such as connected to or positioned about the outer member **426**, to

support, position, and/or connect the telescoping assembly **422** within the opening **424** of the carriage frame **406**.

Further, one or more guiding members **434**, such as rollers, may be used to facilitate and guide the movement of the outer member **426** with respect to the inner member **428**. For example, in this embodiment, the outer member **426** may include one or more windows **436** formed therethrough, in which the guiding member **434** may be connected to the outer member **426** adjacent the window **436** to engage and guide the inner member **428** through the window **436**. As such, the guiding members **434** may be positioned on opposite sides of the telescoping assembly **422** with respect to each other.

In accordance with one or more embodiments of the present disclosure, and as shown in FIG. **4**F, one or more actuators **438** may be coupled between the carriage frame **406** and the transfer car **404** to move the carriage frame **406** with respect to the transfer car **404**, such as horizontally move the carriage frame **406** with respect to the transfer car **404**. An actuator assembly **440** is shown in FIG. **4**F that includes multiple actuators **438**. The actuators **438** are arranged in an end-to-end fashion. In particular, the actuators **438** may be hydraulic actuators that each include a cylinder with a piston rod movably received within and extending from the cylinder. As such, the cylinders of the actuators **438** may be arranged in an end-to-end fashion, in which the cylinders may be directly or indirectly connected to each other. As shown in FIG. **4**F, the cylinders are indirectly connected to each other, as an adaptor **442** is positioned between the actuators **438** of the actuator assembly **440**. As such, in this embodiment, one end of the actuator assembly **440** may couple to the carriage frame **406**, and the other end of the actuator assembly **440** may couple to the transfer car **404**, thereby enabling movement between the carriage frame **406** and the transfer car **404**.

A furnace and a system for heat treating material in accordance with one or more embodiments may be capable of heat treating material, such as a metallic component, and more particularly a tubular member, having a length between about 25 feet (about 7.6 meters) and about 55 feet (about 16.8 meters). For example, the furnace, the quench tank, the manipulator assembly, and/or the material loading station discussed above may each be used to heat treat material having a length of about 55 feet or less. Each of these components, as described above, may be capable of handling material of such sizes due to the configuration used for each of the components. Further, the maintenance may be improved for such equipment. For example, when maintaining the furnace within the present disclosure, the panels of the inner shell may be replaced without sacrificing structural integrity of the furnace, as the outer support frame may be used to support the inner shell. Further, the telescoping assembly used to movably couple the fork assembly to the carriage frame may be replaced by removing the telescoping assembly from the opening of the carriage frame and inserting a replacement telescoping assembly within the opening of the carriage frame.

Although the present invention has been described with respect to specific details, it is not intended that such details should be regarded as limitations on the scope of the invention, except to the extent that they are included in the accompanying claims.

What is claimed is:

1. A furnace for heat treating material, comprising:
- an outer support frame;
- an inner shell connected to and at least partially received within the outer support frame;
- the outer support frame and the inner shell being movable to open and close and to receive and remove material from the inner shell; and
- an arm assembly connected to the outer support frame and comprising an actuator configured to open and close the outer support frame and the inner shell.

2. The furnace of claim **1**, wherein the outer support frame comprises:
- rib assemblies, each extending about at least a portion of the inner shell; and
- support members connected across the rib assemblies to connect the rib assemblies to each other.

3. The furnace of claim **2**, wherein:
- each of the rib assemblies comprises a recess formed therein; and
- the support members are supported from the recesses of the rib assemblies.

4. The furnace of claim **1**, wherein the inner shell comprises replaceable panels connected to each other and connected to the outer support frame.

5. The furnace of claim **1**, wherein the inner shell comprises:
- an exhaust flute operably coupled thereto;
- a gas burner operably coupled thereto; and
- an air blower operably coupled thereto.

6. The furnace of claim **5**, further comprising:
- tubing connected to the outer support frame to provide gas to the gas burner; and
- a support base connected to the outer support frame to support the air blower.

7. The furnace of claim **1**, wherein:
- the furnace further comprises a hearth surface included therein coverable by the inner shell; and
- the hearth surface comprises ridges to facilitate receipt and removal of material on the hearth surface.

8. The furnace of claim **1**, wherein the furnace is configured to rotate about an offset hinge to open and close.

9. The furnace of claim **1**, wherein the inner shell is configured to receive material comprising a tubular member with a length between about 25 feet (about 7.6 meters) and about 55 feet (about 16.8 meters).

10. A system for heat treating a material, comprising:
- a furnace comprising:
  - an outer support frame;
  - an inner shell connected to the outer support frame; and
  - wherein the furnace is movable to open and close to receive and remove the material therefrom;
- a quench tank to receive the material;
- a material loading station; and
- a manipulator assembly configured to transport the material between the furnace, the quench tank, and the material loading station.

11. The system of claim **10**, wherein the material loading station comprises a hearth surface comprising ridges to facilitate receipt and removal of the material on the hearth surface.

12. The system of claim **10**, further comprising:
- a track; and
- wherein the manipulator assembly comprises:
  - a fork assembly configured to receive and dispatch the material from the manipulator assembly;
  - a transfer car configured to move the manipulator assembly along the track between the furnace, the quench tank, and the material loading station; and
  - a carriage frame configured to movably couple the fork assembly to the transfer car such that the fork

assembly is movable within the manipulator assembly to receive and dispatch the material from the manipulator assembly.

13. The system of claim **12**, wherein the manipulator assembly further comprises:

a telescoping assembly coupled between the fork assembly and the carriage frame to move the fork assembly with respect to the carriage frame such that the fork assembly is vertically movable with respect to the carriage frame; and

an actuator coupled between the carriage frame and the transfer car to move the carriage frame with respect to the transfer car such that the carriage frame is horizontally movable with respect to the transfer car.

14. The system of claim **10**, wherein:

the quench tank comprises agitators to agitate a quenching medium within the quench tank;

at least one of the agitators comprises a plurality of ports to agitate the quenching medium through each of the plurality of ports;

at least one of the agitators is positioned along a length of the quench tank; and

at least one of the agitators is positioned at an end of the quench tank.

15. The system of claim **10**, wherein:

the furnace outer support frame comprises:

rib assemblies, each extending about at least a portion of the inner shell; and

support members connected across the rib assemblies to connect the rib assemblies to each other; and

the inner shell of the furnace comprises replaceable panels connected to each other and connected to the outer support frame.

16. The system of claim **10**, wherein the inner shell of the furnace comprises:

an exhaust flute operably coupled thereto;

a gas burner operably coupled thereto;

an air blower operably coupled thereto; and

a hearth surface.

17. The system of claim **10**, further comprising an arm assembly connected to the outer support frame and comprising an actuator to open and close the furnace.

18. The system of claim **10**, wherein the inner shell is configured to receive the material comprising a tubular member with a length between about 25 feet (about 7.6 meters) and about 55 feet (about 16.8 meters).

19. A system for heat treating a material, comprising:

a furnace comprising:

an outer support frame;

an inner shell connected to the outer support frame;

an arm assembly connected to the furnace and comprising an actuator configured to open and close the furnace; and

the furnace being movable to open and close to receive and remove the material from the furnace;

a quench tank configured to receive the material; and

a manipulator assembly, at least a portion if which is moveable between the furnace and the quench tank, configured to transport the material between the furnace and the quench tank.

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